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American Microscopical Society

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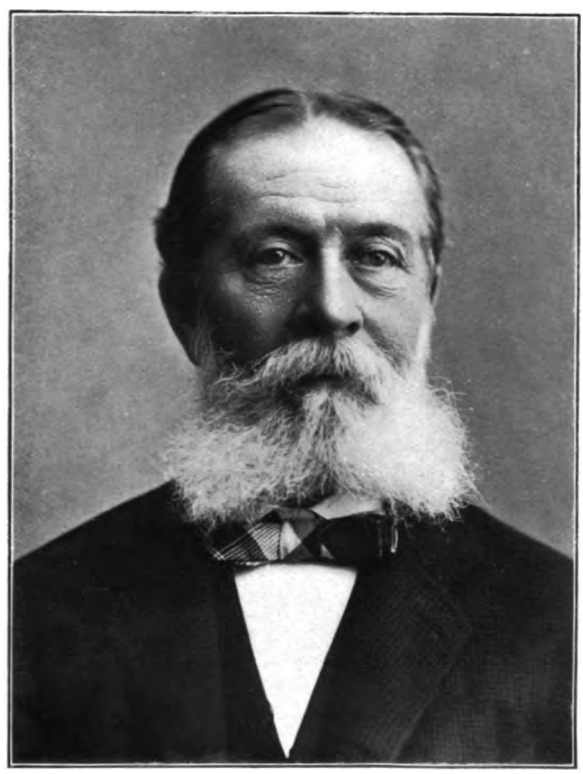

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VOLUME XXXI

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TRANSACTIONS
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Vol. XXXII JANUARY, 1912 No. 1

A BLIGHT OF THE MESQUITE

By F. D. HEALD and I. M. LEWIS

Introduction—During the past three years a diseased condition of the mesquite (*Prosopis glandulosa* Torr.) has been observed in the vicinity of Austin, Texas, but the true nature of the trouble was not determined until the past season when the writers made this blight the subject of special study. Specimens of the blighted mesquite were collected during the prosecution of "A Plant Disease Survey in the Vicinity of San Antonio" and a brief statement concerning the character of the disease was included.[1] The rusts collected during the survey were sent to Dr. F. D. Kern, Lafayette, Indiana, for determination, and specimens of the blighted mesquite were included. The reply was received that the blight was not due to a rust, and a statement followed that similar collections were in Prof. Farlow's herbarium at Harvard. The Harvard collections were not assigned to any definite species of fungus. Specimens from our collections have been sent to Professor Farlow and this information has been confirmed.

Geographical Distribution.—The blight is very abundant in the vicinity of Austin wherever the mesquite is found. It has also been observed at all points distant from Austin where the mesquite grows which have been visited at the proper season of the year. It is not known at present whether the prevalence of the disease is coextensive with the range of the mesquite, but it seems highly probable that the trouble is widely distributed.

1. Heald, F. D. and Wolf, F. A. A Plant Disease Survey in the Vicinity of San Antonio, Texas. Bull. Bureau of Plant Ind., 226:72. 1912.

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Symptoms and Effects.—The blight affects the leaves and produces an effect which has been popularly designated "rust," on account of the resemblance of color to the true rusts and a slight superficial similarity of structure. It first becomes evident during the early part of the growing season, and the trouble is generally well advanced by the last of April or the first part of May. This is very soon after the young leaflets have reached mature size. The blight is very conspicuous on account of the pronounced yellow color which is assumed by the affected leaves. The diseased branches are not generally distributed uniformly throughout the tree but the leaves of certain branches are much more severely attacked than others. The clusters of affected leaves are frequently so abundant that the foliage of the tree presents a marked yellow color even from a distance.

In the early stages of the disease the affected leaflets show a chlorosis which begins at the margin and tip and advances until the midrib is reached. The midrib and some of the larger veins frequently retain the normal green color until somewhat later in the progress of the disease. Very soon minute, golden-yellow nodules make their appearance within the leaflet and they increase in size until they raise the epidermis and then they show on both surfaces as slightly elevated, golden-yellow papillae embedded in the lemon yellow leaf tissues. These pustules represent immature pycnidia. As the disease advances the leaflets begin to shrivel and turn brown at the tip; this discoloration advances until the whole leaflet is involved. Many of the affected leaflets fall before they have been killed and have turned brown, while others are retained until the disease is farther advanced. By the time the leaf tissue has become brown and dead many of the pycnidia are mature, and a careful examination even with the naked eye will show that they have opened at the surface by a narrow slit or a slightly irregular fissure. By midsummer or earlier all of the diseased leaflets have disappeared and the affected branches are completely defoliated. There is no evidence of a *direct* attack of the leaf rachis or young twigs. The casual organism appears to be confined to the leaflets. Our observations indicate that many of the seriously affected branches are killed.

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This is borne out by the presence of many dead twigs upon diseased trees which we have had under observation for several years.

Etiology.—The blight of the mesquite described above is caused by a parasitic fungus which we have not been able to refer to any described species. A superficial examination might lead one to refer the causal organism to the Uredineae, but a careful study has revealed its true nature.

Fresh or dried material gave very poor results. The material for the detailed study of the fungus was prepared according to the methods employed in modern morphological investigations. Small pieces of leaflets showing both young and advanced stages of the disease were fixed in both picric and chrom-acetic acid fixing solutions, imbedded in paraffin and cut into sections of varying thickness. The stain employed was the triple stain of Fleming. The tissue fixes readily and no difficulty was experienced in securing excellent series of sections. The sections were supplemented in study by teasing out the fresh pycnidia in water.

The pycnidia in their young stages consist of dense aggregates of fungous cells embedded in the mesophyll of the leaflets. They are globular or elongated and finally reach a diameter almost equalling the thickness of the leaflet. Up to this time they consist of an undifferentiated mass of closely compacted, fungous cells, without the appearance of any pycnidial cavity, and hence resemble small sclerotia. There is a slight hypertrophy of the host tissues adjacent to the pycnidia and this together with the growth of the pycnidia gives the leaflet its characteristic papillate appearance. These aggregates of fungous cells have a pronounced orange yellow color (Fig. 3). The leaf tissue is apparently destroyed and replaced by the aggregates of fungous tissue. The mycelium does not extend generally through the leaf tissue but appears to be confined entirely to the pycnidial nodules.

By the time the sclerotial mass has nearly reached mature size a cresentic cleft or fissure, the beginning of a pycnidial cavity, may be seen in transverse sections. The cells adjacent to the cleft elongate and assume a palisade-like arrangement, and later develop the spores. The cavity is always longer than deep, and even when completely developed retains more or less of a cresentic form in

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transverse section. The cleft appears in an excentric position and is generally nearer the outer surface, so that a mature pycnidium shows a dome-shaped mass of tissue which rises into the pycnidial cavity (Fig. 5). The pycnidial wall is many cells thick, and uniform in structure, but thins out somewhat above where it breaks to form a more or less elongated or irregular fissure (Figs. 2 and 5).

The conidiophores line the entire interior of the pycnidial cavity forming a continuous layer of cylindrical, pointed filaments from which the spores are constricted. The spores are unicellular, continuous, hyaline, slender thread-like, 25-30x2-2.3μ, and either straight or tortuous. No definite ostiole is developed but when the pycnidium reaches maturity the external wall ruptures and a linear or irregular fissure is formed through which the spores are extruded. The pycnidia may reach maturity while the leaflets are still hanging on the tree or not until they have fallen, but the leaf tissues are generally brown and dead before they are perfectly developed. Many of the pycnidia fail to develop a pycnidial cavity and remain as sclerotia-like masses of fungous tissue. Many of these aborted pycnidia may be found upon the fallen leaves. The fact that many pycnidia are aborted and that perfect maturity is not reached until a comparatively late stage in the progress of the disease, made the determination of the character of the trouble more difficult.

All attempts to grow the blight fungus in cultures have given only negative results. Poured plates made from pycnidia which had been teased apart in sterile bouillon gave no growth of a fungus. In a number of cases pycnidia were carefully dissected out from the leaf tissue and planted in glucose agar plates, but no growth resulted from any of the plantings. In all culture work carried out the spores have failed to germinate.

The manner of primary infection, and the time when this infection takes place have not been determined. It seems that a perfect stage upon the fallen leaves later in the season might be produced. Old fallen leaflets from the preceding season, collected from beneath trees which show an unusual amount of infection, frequently show perithecia. A single species appears to be fairly constant. The ascospores from these fruits grow readily in cultures on the common media, but in all cultures the colonies have failed

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to produce either pycnidia or perithecia. It is impossible to state definitely at the present time that a relationship exists between the ascogenous form on the fallen leaves and the blight fungus. Work is in progress which it is hoped will throw some light on this point.

Technical Description.—An examination of mycological literature has failed to yield any known genus to which our fungus can be referred. Although the material studied represents only a conidial stage it seems advisable to describe it at present as belonging to a new genus and species, even tho later study may reveal a connection with a known perfect stage.

Scleropycnium.—Heald and Lewis, n. gen.

Pycnidia when young sclerotium-like, immersed in tissues of host, golden or orange colored and becoming hysteroid and erumpent with maturity, and less conspicuous; pycnidial cavity appearing as a cleft, always surrounded by wall many cells thick. Parasitic. Mycelium obsolete.

Scleropycnium aureum Heald & Lewis, n. sp.

Pycnidia numerous, globular or oblong, separate, smooth, immersed in the mesophyll, later becoming slightly erumpent, and amphigenous, orange yellow, hysteroid, 225-250x250-400μ. Wall many cells thick, cavity generally excentric. Basidia simple, cylindrical, 15-18x4-5μ, forming a palisade-like layer lining the pycnidial cavity. Conidia not catenulate, continuous, hyaline, narrow cylindric, 25-30x2.3μ, straight or tortuous.

On living leaves of mesquite, (Prosopis glandulosa Torr.) and causing a characteristic blight.

This fungus appears to be related to the *Scolecosporeae* of the *Nectrioidaceae.*

School of Botany,
Austin, Texas.

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EXPLANATION OF PLATE

Fig. 1. An enlarged leaflet of the mesquite, showing the distribution of the pycnidia.

Fig. 2. Small portion of an affected leaflet, showing several mature pycnidia which have opened by a linear or irregular fissure.

Fig. 3. Transverse section of a young pycnidium before the appearance of a pycnidial cavity. x 300.

Fig. 4. Transverse section of a nearly mature pycnidium. This does not show the typical excentric position of the cavity. x 110.

Fig. 5. Transverse section of a mature pycnidium from which spores are being extruded. x 460.

Fig. 6. Conidophores and spores. x 600.

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THE LAKES OF GLACIER NATIONAL PARK.

By Morton J. Elrod.

II*.

LAKE LOUISE.

The trail from Glacier Basin passes over the shoulder of Lincoln Mountain, around the shoulder of Gunsight, and drops down almost to the lake, lying at an elevation of 5,974 feet. As one rounds the angle of the mountain the lake comes into view suddenly, a beautiful sheet of water about a mile long and half as wide. High cliffs on all sides except to the south rise from the water. On the west side is a narrow strip of land which makes an admirable camping site. The first view is had from a high elevation, whichever way the traveler may be going, and is very impressive. The way leads almost to the water's edge, and a camp on the shore will be very pleasant.

We camped here early in September, 1909, staying over Sunday, September 5. Jones and I walked over Gunsight pass on the 4th. We rode from camp at Gunsight lake to the highest point on the trail where it begins to descend, before making the final ascent to the pass, the elevation being about 7,150 feet. It was a hard pull. We were both heavily loaded with big cameras and collecting material, and I was too ill to do anything but stumble along. The pass was reached about five in the evening. Lake Louise presented a most beautiful view, 1,300 feet below. A slight breeze was blowing, rippling the surface. The position of the countless small waves reflected the sun's rays directly toward the pass and in our eyes. The result was to give the lake the appearance of molten gold, brilliant at the upper central part of the water, fading outward toward the edges. So gorgeous was it that one could look at the lake only with eyes alomst closed, like looking at the sun. Such a sight

*The first article in this Series appeared in Volume XXIX, No. 2.

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one rarely sees. It was more dazzling than sunsets on Flathead lake, which are beyond description. For a long time we sat in the pass, reveling in the splendor of the view. The cameras were brought into use, and the resulting photographs, when colored, give a fair idea of the colors, although the most brilliant tints fail to do justice to the picture. Slowly we picked our way down the rocks to the lake and to camp, avoiding the trail. A few minutes after our arrival at camp the sun sank behind the high crags to the west, and immediately the air became quite chilly.

The lake shore was searched the following day for insects, frogs, snakes, etc., and the lake waters examined for microscopic life. It was so cool that insects were scarce. Two frogs were found, one not yet fully transformed, still retaining a portion of the tail, although it was September. No snakes were seen. There were no squirrels calling in the scrubby timber. While we ate breakfast a goat was seen slowly working his way along the cliffs above us. For fifteen or twenty minutes he was in view, so close glasses were not needed, then disappeared among the rocks at the pass.

Collections of entomostraca were made from the water on the morning of September 5, 1909. The rectangular dredge was used, with butcher's linen top sewed to iron frame and fine silk bolting cloth for bag. The apparatus was thrown out as far as possible, allowed to sink, and hauled in. It was thrown out some 40 or 50 feet. At each haul the microscopic life was washed out in a large bottle, then transferred to a smaller bottle and preserved. The act of throwing out and hauling in the dredge was repeated several times until by an accident the silk net was torn, and no more collecting with it was possible.

There was an abundance of microscopic life. No attempt was made to determine the material quantitively. Such a thing was impossible. The big red entomostracan, so abundant in Peary and Nansen lakes at the top of the rocks at Sperry glacier wall, was the most abundant species.

The results of the work with the net indicate that the lake has an abundance of entomostracan food for fish, and if young fry were planted they would doubtless do well. The lake waters fall over a cliff immediately at the outlet into a second lake 1,700 feet lower.

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This lower lake is full of fish, and is a great resort for fishermen, although somewhat difficult of access. With Lake Louise stocked with fish the tourist would find it a delightful place for a camp. It is easy of access, there is plenty of wood, the scenery is very impressive, and climbing may be indulged in to the heart's content. From the high cliffs just back of camp a high waterfall breaks into spray before reaching the talus below. The stream heads in snow banks in a big basin, invisible for the cliffs. A second fall comes over the rocks above the lake, the water supplied by a small glacier just east of the pass. The trail passes at the foot of the fall, reached by an easy walk. The cliffs of Mt. Jackson, across the lake from the trail side, are high, abrupt and very impressive.

Botanizing is good. While the timber is short and scrubby, it is nevertheless quite abundant, every shelf and protected place supporting its clump or clumps of trees. The patches of timber here and there among the cliffs give them added beauty, and show where the shelves of rock are, and often indicate a way up, if one is inclind to prospect. Mosses, lichens, and ferns, as also alpine water loving plants, abound among the rocks and in the crevices along the water courses or on the scree or talus below the snow beds or ice. Insects are doubtless abundant on warm days, although at the time of our visit scarce because of the lateness of the season. Frost was on the ground in quantity the morning of September 5. We were not searching for insects, but from the character of the country and its location they are surely abundant.

The depth of the lake was not then determined. So far as then known no boat had been placed on its surface. In 1910 we planned to visit the place again when provided with a canvas boat, but plans miscarried, and the visit was not made. From appearances it is quite deep. It surely does not freeze to the bottom, and fish would undoubtedly find a quiet home and do well.

From Glazier Basin to Lake Louise is about three hours, more or less. Fish fry transported to Lake Louise would be attended to last at Glacier Basin, as there is no water between that place and Lake Louise. It does not seem a difficult task to stock the lake with fish. It is large enough to furnish a home and food for a large number. They would be confined to the waters of the lake, as there

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is no portion of either the inlet or outlet which fish could travel. But that makes little difference. Now that the lake is a part of a government reserve it should be stocked with fish for the benefit of the thousands who will doubtless camp on its shores. The traveling public visiting the park will surely visit the lake in large numbers, for it is one of the scenic spots of the park, is easily reached, and is a delightful place in which to linger. Nansen, Peary and Louise may be attended to at one planting. Gunsight, across the divide, may be stocked from the other side, via St. Mary lake.

In 1911 I made another trip through the Park and stopped over night at Lake Louise. We worked on Gunsight lake in the forenoon, packed up just after lunch, started up the trail to the pass about two in the afternoon, and made camp at Lake Louise about six. The day, August 23, was one of the most perfect of the entire trip. Owing to the high cliffs of Gunsight west of the lake the sun sets early. The lake was in shadow when we arrived at its shore, but the golden summit of Jackson was brilliant in the evening sunlight, and the distant summits to the south, outside the Park limits, had an unusual clearness of form and outline.

While the boys made camp and the cook prepared dinner I put the canvas boat together. The job for me took forty minutes, the best record for the summer. After the evening meal Duffy, our cook, and myself hastened out on the lake. I wished to do the work before darkness came on.

The surface net only was used. Near shore no great abundance of life was found. In the middle, where the water was deepest, one drag of a few hundred yards resulted in almost filling the little bucket of the net with the blood red entomostraca and a clear, transparent species in lesser numbers. One haul gave an abundance of material. There is an enormous amount of life in the lake. Owing to the lateness in the day and the depth of the water the bottom dredge was not used.

The depth of the lake is as follows:

Upper end, 200 yards off shore, 88 feet.
In the middle, half way down, 118 feet.
Almost two thirds down, 244 feet.

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Water temperature, 40 F.
Air temperature, 52 F.
Time, 7:30 p. m., August 23, 1911.

A lake as large as Louise, with a depth of 244 feet, will support a large amount of fish life, even though they may be confined to the waters of the lake. The lake has an elevation of 5974 feet, 698 feet higher than Gunsight, 2119 feet higher than Avalanche lake, 1501 feet higher than the upper St. Mary, and 1113 feet higher than McDermott. It is 599 feet higher than Hidden Lake, which is 2231 feet above Lake McDonald. Louise is therefore 2830 feet, or a little more than half a mile, above Lake McDonald.

But Louise is in a basin on the south side of Gunsight pass, exposed to the southern sun. Although the sun rises late and sets early for the lake surface, it nevertheless shines with powerful effect during every day when not obscured by clouds. This would not be true of Avalanche, Hidden or Gunsight lakes. The snow around the lake and on the slope of the pass must melt early in the spring, hastening the breaking of the ice in the lake. This melting snow will bring down quantities of food from the grass and timbered slopes above, even from the bare rocks. Although at a high elevation the lake must remain ice free quite late. The prevailing air currents are from the lower regions upward toward the pass, blowing over the lake on the way. These will carry insect life for food. They are warm currents in the fall, as proven by experiments elsewhere, and will retard freezing on the lake.

Everything considered, it seems clear that fish will live in the lake. They stand a poorer show than they would in almost any other lake examined, due to the absence of creek inlets and outlet, and to the elevation. But the lake is deep, and just now full of life. Tourists will find the lake a splendid camping site. They will enjoy the pass, the scenery, the lake, and all surrounding it, as well as any other place in the park. When they begin to camp on the lake shore and fish there is little chance of the increase of fish beyond the capacity of the lake to furnish food.

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DESCRIPTION OF ILLUSTRATIONS

Plate II—Toward the summit of Mt. Jackson from Gunsight Pass, above Lake Louise. The unnamed glacier, only a part of which is visible, drains into Lake Louise. Other ice masses, similar but smaller, make up the water supply. The summit on the right is Jackson, 10,023 feet elevation. Note absence of vegetation and precipitous cliffs.

Plate III, A—Lake Louise from continental divide at Gunsight Pass. The view is to the south. The rippled surface of the water gave a beautiful golden reflection of the sun at the time the picture was taken. The water from the lake drops over cliffs 1,700 feet high. Note the precipitous rocks and scant vegetation.

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DEPARTMENT OF SUMMARIES

TO BE DEVOTED TO DIGESTS OF PROGRESS IN BIOLOGY

While the *Transactions* will continue to be primarily a Journal of research in micro-biology, it is recognized that the field has become so broad as to preclude the possibility of frequent articles in any one of the departments of special interest. Because of this it will be the policy to present, from time to time, supplementary digests of the progress being made in the various fields of micro-biology. It is also proposed to introduce similar summaries of the progress made in some departments not represented in our articles of research. This is done with the feeling that such reviews will increase the permanent value of the *Transactions* to all who may not have access to a large list of technical biological journals, nor the time to make the survey for themselves.

PROGRESS IN EVOLUTIONARY THOUGHT

SOME LATTER-DAY ASPECTS OF "DARWINISM."

By J. F. Abbott.

A lecture given before the faculty and students of Washington University Jan. 9, 1912.

If any one thing can be taken as a symbol of the present time, I fancy the most appropriate would be the hammer. Not only is the hammer the symbol of constructive industry so characteristic of our age, but it may also typify the spirit of iconoclasm, which is equally, if not more strikingly, characteristic. From the muck-raking of a popular magazine to the calm, deliberate, destructive criticism of a system of philosophy, now is essentially a time of making over. The present generation has no reverence for traditions of the past unless they be in harmony with the point of view of the present.

It is by some considered a sort of poetic justice that the image of the greatest iconoclast of modern times, in effect if not in purpose,—Charles Darwin,—should be torn from its pedestal by those upon whose shoulders his mantle of leadership in Biology has fallen.

For in spite of the fact that the theory of evolution is far wider than Darwin's hypothesis of Natural Selection, and that Darwin's theories were anticipated in many ways by Maupertius and others; in spite of the fact, too, that Darwin's own personality was the opposite of aggressive, the fact remains that Darwin's name stands as the personification of that intellectual insurgency which shattered

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the placid conventions of centuries, and although Darwin himself, without question, worked with an eye "single to the pursuit of truth" for its own sake, yet the publication of "The Origin of Species" in 1859, like an absent-minded prod of an ant hill with a walking stick, instantly set up a commotion which took decades to subside.

Like a spark in prairie grass in the autumn, the fire of the idea at once spread in all directions, biological interpretations of history, of philosophy, of psychology, of economics, of astronomy, sociology, of pedagogy soon became the order of the day and the world was apparently fully persuaded to the new way of thinking.

This had little to do, perhaps, with the "origin of species" as such. What, then, was the significant kernel of Darwin's speculations that was so fruitful of growth and so capable of transformation?

Briefly, it was this,—the substitution of a natural for a supernatural explanation of the material organic universe. It was this that aroused the united wrath and enmity of the Church and engendered the bitter disputes which occupied the sixties and seventies.

To Darwin more than to any one else, perhaps, was this directed, for, while evolution was in the air not only throughout the 19th century, but during the larger part of the 18th as well, and although biology came into the debate comparatively late, yet the polemic ability of Huxley and the imperturable materialism of Darwin combined to draw upon the biologists all the theological lightnings with which the sky was charged.

The "anthropocentric" conception of man as the center and chief factor in a universe created for his especial use and enjoyment was decidedly a hard one to forego, and in spite of the gradual acceptance of the evolutionary standpoint during the latter half of the century past, there has always been a small remnant, silenced but unconvinced, whose recantation has been much like the famous one of Galileo.

Biologists have discovered that the fundamental characteristic of living matter, by virtue of which it is alive, is mutability, and that stability is synonymous with death. It is not otherwise with hypotheses or with ideas. So long as they retain the vital spark we must expect their nature to be at least susceptible of change. When

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an hypothesis has passed this stage, it is no longer a working basis, but has become a creed.

Darwin's theory of "Natural Selection", announced a half century ago, struggling for recognition, and finally achieving it, has been no exception, and the addition of new facts, the assembling of a mass of data, beside which even Darwin's patient and painstaking accumulation seems insignificant, could not otherwise than alter our point of view. To those, however, to whom the indefinite is abhorrent and who find a certain soul-satisfaction in a rigid creed, the calling into question, on the part of biologists, of some of the fundamentals of Darwinism has been hailed as a tardy renunciation of heresy, for which the only alternative is a reversion to first principles.

One of the curious consequences, then, of the increase in interest and knowledge along evolutionary lines has been a recrudescence of what may be called anti-Darwinism literature, and this has been not alone the product of hidebound conservatives. Among biologists there have not been lacking those who feel that Darwinism has had its day and have hailed with satisfaction various subsidiary hypotheses as "new theories of evolution." It is not to be wondered at, then, if the layman is somewhat puzzled, and doubtful of what he should think or believe.

In most people's minds the primary difficulty, perhaps, is in the confusion of two radically different conceptions—Evolution and Darwinism. These are not synonomous terms. Evolution would, perhaps, have been the philosophical basis of modern thought even if Darwin had never lived, and the refutation of the whole principle of natural selection would not alter in the slightest the theory of evolution as such, since Darwinism is but one of several possible explanations for an evolution otherwise conceded to exist.

Darwinism, then, must stand or fall on its merits, and if it falls we must seek some other explanation of the method of evolution.

To deal adequately with the history of the Theory of Evolution, even if details be omitted, would require not a lecture hour, but a semester course. One point, however, needs a word of comment.

Since the mind of man first began to ferment and ideas other than those of food and shelter rose to the surface, two aspects of

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nature have claimed his attention, one the *static*—dealing with things as they are, always have been and presumably always shall be—the other, the *dynamic*, that recognizes the apparent stability of nature to be illusory and that, to quote a familiar phrase,—"the only stable thing in the cosmos is the fact of change."

The latter was more especially the trend of earlier thinking, the former was set and crystallized by the influence of the mediæval church, and it was because scientific progress in the 19th century again brought men around to the dynamic point of view that the inevitable clash occurred between ecclesiastical dogma and scientific speculation.

It is well to keep clearly in mind the implications of these two points of view, for they are mutually exclusive, and to try to combine them is to invite mental anarchy. To think of the Universe (by which is usually meant that atom of it called earth) as a stable something, unchanging in its physical aspects, permanent in its organic types or species and immutable in the intrinsic nature of what we call human spirit or soul,—that is one thing. To conceive of the Universe, physical and spiritual, as a constant flux, in which matter has no stability in form (if in substance), where time and space are but artificial concepts of the human mind, that is quite another. Let there be added to this constant changefulness of things the concomitant of law and order and we have the evolutionary standpoint. The other is the concept of special creation, which was characteristic of the mental attitude of Europe (with certain exceptions) until the middle of the last century. The former has been the characteristic point of view since. The "Origin of Species" stands at the dividing line, for although it would be quite incorrect to assert that this book was the *cause* of the change in the point of view of the western world, yet, like a burning glass, it certainly focused the various divergent rays of evolutionary thought and brought to a blaze the smoldering fires of opposition to the established order of thought. It offered a mechanical explanation of the evolutionary process in the organic world and demanded no superphysical agencies to bring it about. Herein was its great and novel strength and also, as we shall see, its weakness.

It has seemed worth while, therefore, to review the standpoint of the Darwinian Theory in the light of present day advances and

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try to discover just where we stand, since the adage that "where there is so much smoke there must be fire" is not without its empirical justification. Since the greatest danger in such an exposition is that of discursiveness, I shall try to confine myself pretty closely to my topic. I shall not take time to discuss Evolution in its broader aspects, either historically or analytically. I shall take it for granted that you are all Evolutionists in this general sense. If any one truly believes that Adam and Eve are historical characters and that the Mosaic account of the Creation is anything more than a childish tale, suitable for childish minds, I take no issue with him. I merely do not understand the workings of his mind, nor, I fancy, will he of mine.

The outlines of the Darwinian Theory are no doubt familiar to most of you, but it may not be out of place to review them, since unless we understand perfectly what the original hypothesis is we are hardly in a position to appreciate criticisms of it.

The first thing that strikes the attention of the naturalist in the field is the astounding prodigality of Nature,—the wasteful largesse of individuals,—of life itself.

"Nature", to quote Tennyson,

> So careful of the type she seems,
> So careless of the single life,
> That I, considering everywhere
> Her secret meaning in her deeds,
> And finding that of fifty seeds
> She often brings but one to bear.

The poet did not avail himself of his poetic license in limiting the number to fifty. The more prosaic minded scientist knows that fifty myriads would more nearly approach the fact.

A few examples will make this clear. We learn that an eel may lay 15,000,000 eggs. the oyster ½ to 16 million, the codfish 60 million. Yet if any considerable number of any species survive, these huge numbers would seem unnecessary. Let us take as an extreme example the hypothetical case of an annual plant producing two seeds only. If each seed sprouted and survived, at the end of twenty-one years there would be 1,048,576 plants! Jordan estimates that if all the fly eggs laid in a single day in a large city should actually hatch out, the inhabitants of the city where this happened could not

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escape in time to avoid being smothered by the mass of hatching flies. The common mosquito completes its life cycle in about ten days. Each female lays 200-400 eggs. Let us take the minimum number, 200. If one half of these are females there will be 100 left as the first generation. It is a startling problem in arithmetic to figure out how many mosquitos a single summer would produce if all survived. We see at once that it is not the ratio of increase that is significant, but the ratio of *net* increase, which is a very different thing. Out of the hosts of individuals born into existence only a few survive each time, and a constant balance is maintained. When this balance is disturbed, as in the case of the importation of rabbits into Australia, we have a startling instance of the unchecked productivity of Nature. The question now comes up,—"Are those individuals that survive merely the lucky beneficiaries of chance and has their selection been indiscriminate, or has there been some criterion of selection, some standard attained, that Nature permits them to survive and propagate their kind?" The Darwinians hold to the latter view, and this second step in the hypothesis now demands examination.

Conceding this elimination to be an indisputable fact, what is the basis for the postulated selection? We recognize that variation is universal, but few except the naturalist have any idea *how* universal it is, how all-pervading, affecting not only form and structure, color, etc., but habits and physiological traits, invisible, but very significant withal. Another thing about these variations, which have been called fortuitous or chance variations, to distinguish them from other kinds, to be mentioned later, is the very important fact that they are susceptible of mathematical treatment, i. e., may be studied quantitatively instead of qualitatively, which is a great advance. If I shake the dice out of the box a thousand times, although I can never predict just what any one throw will be, yet I can figure out very exactly, by the Law of Chance, just how many of one combination will turn up out of the whole lot. In the same way the insurance actuary, although he may not have any second sight as to when I shall die, yet knows to a fraction just how many men of my age out of every thousand are going to die during the next twelve months. In the same way, although I cannot tell just how many rays any one daisy may have, yet out of a thousand I can tell how

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many will have 12 rays, how many 21, and how many 40. For we have learned that the greater number of variants are found about the middle dimension, the mean, and the farther away we get from such a mean the fewer examples we find out of a thousand, so that of the lowest and highest extreme there may be only one or two. We may plot these dimensions in a curve, and when we do so we find that the curve is of the class known to mathematicians as the "binominal curve."

Now another aspect of existence claims attention. In spite of this all pervading variability, men and dogs and oak trees are all pretty much like other men, dogs and oaks. Particularly they are much like their immediate ancestors,—a resemblance which we recognize by the term Heredity. Heredity and variation are but two sides of the medal. Comparing an individual with its ancestor we see that there are many points of similarity. These we class as hereditary, the balance of dissimilarity we call variation. It must be kept in mind that neither of these terms stand for concrete things, but only for relations,—comparisons, as a matter of fact. In the relative proportion of these two constituents,—the warp and woof of the individual fabric,—there enters another and significant factor.

Ole Olson, here, resembles his mother so closely that any one's attention is attracted at once to the phenomenon. His brothers and sisters are all apparently cast in the same mould. His uncles and aunts bear a family resemblance, his great grandfather perhaps less of a one, but altogether they class themselves first as Olesons, next as Scandinavians, then as Europeans, then as Caucasians, then as human beings. The native of Russia or of sunny Italy is also a European and a Caucasian, although not even a child would think of calling him a member of the Oleson family. Wu Ting Fang is a human being as well, although no disguise could make one mistake him for a European. It needs no argument to prove that the reason the Olesons look alike is that they are of one family. The reason they are unlike Caruso is that they are more remotely related, but that both Oleson and Caruso look more alike than they resemble Wu Ting Fang is but other evidence for what we know already,—that they are related to each other much more closely than either of them to the Mongolian. In other words, individuals resemble each other largely in direct proportion to the closeness of their re-

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lation,—a rule that works both ways, for, as we say, "like begets like".

Acting on this belief, Darwin claimed that since in the struggle for existence the best adapted survive, and survive on account of possessing, accidentally, as it were, certain favorable variations, then these very variations, like begetting like, would not only perpetuate themselves, but would become intensified generation after generation. Now, not only the organic but also the inorganic universe is in a constant state of flux. The "rock-ribbed hills" are as transitory as the April snowflake in the eye of Him for whom time does not exist. If the environment were constant it would not matter whether a species varied or not. But with a changing environment, the perpetuation of selected types, based on appropriately favorable variations, permits of a flexible adjustment of the specific type to the new conditions; in other words, the formation of a new type or species. This is the Origin of Species according to Darwin.

Let us, at the risk of being tedious, give a brief summary of this train of thought.

Given, first, the fact, which is undeniable, that of every type of animal or plant there are born into existence an infinitely greater number than can possibly find food or room to exist in, and we have as a corollary, that of this multitude, only a few can survive to propagate the series—this is the famous "Struggle for Existence".

Given, in the second place, the fact, now a thousandfold more emphasized than in Darwin's time, that every individual animal or plant, and indeed every part of an individual, is subject to variation within limits, so that there is never such a thing as a duplicate in nature; combine this variation with the fact of heredity, which implies that the progeny are, as a rule, more nearly like the parents than they are like anything else, and we have a basis for elimination, i. e., those individuals in the struggle for existence whose variations are such as to lend even a slight advantage in that struggle are the ones who will survive and thus bring about the "Survival of the Fittest."

Given, in the third place, the survival of the fittest, and combine with it a changing environment such that those characters, once of advantage, become less advantageous than other characters produced by this same variation, and we have through the constant

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elimination, in the never ceasing struggle for existence, the establishment of a new type adapted in this way to the new environment, but one adapted, remaining fixed and only subject to elimination in conflict with other types better adapted.

Such in outline is the essence of Darwinism,—a mechanical theory of the origin of species through the elimination of the unfit and the survival of the fittest to propagate their kind. The words "Natural Selection" were used by Darwin in the belief that essentially the same process takes place in nature that the plant or animal breeder uses, in selecting for breeding those individuals that conform to an ideal type.

The latter-day opponents of Darwinism may be divided into two groups: those who deny in toto that there is such a thing as the natural selection to which I have referred; and those who, while accepting the existence of such a factor, yet deny its universal application, and in particular deny its function in the formation of new species, offering in its place substitutionary or emendatory theories. The former are truly destructive critics to be refuted or accepted. The others offer something else which must be considered. To the former group belong such men as Dennert[1], Fleischman[2], Wolff[3], and Driesch. In the second group may be included De Vries[4], Delage[5], Eimer[6], and Morgan[7].

To use a rather trite comparison, the chain of steps involved in the uprearing of a theory is no stronger than its weakest link. Any one fact disproved, or any one deduction shown to be inconsequent, straightway reduces the theory builded on that fact or deduction to the rack of an unproved speculation.

For the opponents of the natural selection theory to show that any fact of nature is inexplicable on the basis of that theory is to shatter the whole hypothesis, since as a comprehensive explanation of the method of evolution, Darwinism must be all or nothing. That there are such inexplicable facts is believed by many biologists,

1. E. Dennert, Vom Sterbelager des Darwinismus, 1903.
2. A. Fleischman, Die Descendenz-Theorie, 1901.
3. G. Wolff, Beitrage zur Kritik der Darwin'schen Lehre, 1898; Der Gegenwartige Stand des Darwinismus, 1896.
4. H. De Vries, Die Mutationslehre, 1901.
5. Y. Delage, L'Heredite, 1903.
6. Th. Eimer, Orthogenesis der Schmetterlinge, 1897.
7. T. H. Morgan, Evolution and Adaptation.

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though it does not of necessity follow, as some have thought, that because the all-sufficiency of the hypothesis may have been controverted, its all-importance as a significant factor in the argument can be left out of consideration.

Briefly summarizing the points that have been made against the natural selection theory we may note, first, the insignificance of fluctuating variations, such that they can have no possible selective value. For example, Kellogg[8] mentions the fact that the white pelt of polar bears is of very great aid in securing food, but that it is almost impossible to conceive that the few white hairs on an originally darker ground could have had any selective value or could have played any part in the struggle for existence between such a bear and a normal one. Herbert Spencer[9] calls attention to the fact that a certain Greenland right whale weighing about 44,800 pounds had femurs weighing together three and a half ounces, "while a sample of the razorback whale (Balonoptera musculus) 50 feet long, and estimated to weigh 56,000 pounds, had rudimentary femurs weighing together one ounce; so that these vanishing remnants of hind-limbs weighed but one 896,000th part of the animal." It is indeed questionable whether the advantage or disadvantage in nourishment or weight accruing to the whale with the two-ounce femur in comparison with one, let us say, with a four-ounce femur would be significant in the struggle for existence. Yet according to Darwin's hypothesis, there would be no possible method for developing such a condition except through the elimination of individuals having a less well-adapted structure. This objection naturally occurred to Darwin, but he believed that in the intense struggle for existence even the minutest differences would be significant in determining which should survive; and later biologists have had their attention attracted to the fact of correlation in variation, by virtue of which characters of no significance in themselves are linked, as it were, with other characters which have selective value. These characters might often be physiological and hence invisible, but of none the less significance in the life and activities of the creature possessing them.

A second point well made is the inutility of many specific characters. For example, one of the largest groups of beetles, the

8. L. Kellogg, Darwinism To-day, 1907.
9. A Rejoinder to Professor Weismann, Contemporary Review, Sept., 1893.

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Carabidæ, is divided into two special groups by the practically invariable character of the presence of two microscopic hairs over the eye, or of only one such hair. The scientific imagination is embarassed in an attempt to read utility into any such character as this. The same is true of many color markings, notably in those molluscs whose beautiful color markings are covered by the mantle and visible only when the animal is dead and the shell cleaned. The answer made to this objection is that many characters now useless have been useful at some earlier stage in phylogeny and have lost their function through change of habit. The specious argument is also often heard that it is not for mere man to decide what is useful or not to an organism far removed from his own experience.

A third important point is found in the fact, easily demonstrated, that according to Quatelet's law, the extreme variants are always fewest in number. These extreme variations would be the ones of most value in selection, but it is hard to see how they could help being swamped out in promiscuous mating and brought back to average mediocrity, because of the fewness of their numbers, since the chance of their mating together and thus perpetuating the variation is infinitely smaller than that of losing the advantage by mating with an individual without the variation.

Fourth, in the same connection, although Darwin's hypothesis is based entirely on chance variations, it is almost absurd to believe that advantageous variations should occur in many individuals at the same time; yet, to have any effect on the mass, this fortuitous variation in a given direction is a necessity to assume. For example, in bilaterally symmetrical animals it has been found that the index of variability in the right and left sides is very often quite different, yet the purely mechanical theory of natural selection is asked to explain how, for example, two eyes that focus together may arise in conformity with the law of chance. The pro-Darwinians, who try to answer this objection at all, are obliged to call upon some new supporting hypothesis, such as orthogenesis or directive variation, which is a very different thing from Darwin's fortuitous variations.

Another very potent objection, raised long ago by Mivart, is this: that many characters easily recognized to be very useful to the individual and hence easily conceived to be the basis of selection

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on account of their usefulness, are so, however, only when they have become perfected, and are of no use, and hence have no selective value, in their incipient states. Many such examples occur to anyone: the electric organ of the torpedo fish, for instance, or the cameleon's tongue, or, to use an even more vital illustration, one to which Kellogg (l. c.) calls attention, that classic example of all evolutionary writers, the mimicry of one insect species by another. We have two kinds of resemblance that must be recalled, one, the general resemblance by virtue of which an animal resembles its whole environment, as a white fox on the snow, or a lizard on a sand-bank; and the specific resemblance which we call mimicry, in which the animal, usually an edible insect, imitates another inedible species in the finest details, and thus escapes destruction by its natural foes. Think a moment and you will see that for such a resemblance to have any influence in the struggle for existence it must be all or nothing; an approximation would not be of any value, yet by the Darwinian hypothesis such a final form must have been reached by the gradual elimination of minute variations, each of which would have selective value, so that in the end a typical mimetic form would remain.

Perhaps the most vital objection of all is this: that fluctuating variations, which are the only kind considered by Darwin, are always confined to plus or minus changes in something already existing. Consequently the progress of such variations must always be linear. They are quantitative, that is, and not qualitative. For instance, an appendage may on the basis of such variations become longer or shorter, heavier or lighter, but the appendage must previously exist before it can vary in this way; fluctuating variations cannot explain the original appearance of the rudiment. Nothing is more evident than that evolution is polygenetic and qualitative, so that it would seem necessary, even if natural selection is the basis for the development of new forms, that some supplementary influence should intervene at the proper time to produce qualitative differences for such variations to work on.

One other development of the study must be mentioned: it has been established, first by Kropotkin and later by others, that the struggle for existence about which so much has been said, while real enough, no doubt, is not so universal as previously suggested.

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First, the factor of what has been called "mutual aid" must be taken into account, the development of the social instinct and the superiority of a species,—say of bees,—in which a social organization is perfected, over a species of solitary bees, such that advantages accruing through merely fluctuating variations of the individual would be of very little significance in comparison with the advantage gained through co-operation. Second, it will be readily seen that the competition, real as it is, between the hosts of individuals born into the world is thoroughly over before sexual maturity, as for instance in the May-flies, which spend a year or two as aquatic larvæ and then emerge for a few brief hours of adult life as winged insects. It will be readily seen that if adult characters are used as a basis for selection, the "struggle for existence" in this case, and the resultant selection as individuals must have been over and done with before metamorphosis, (omitting of course all reference to sexual selection). Third, among the lower forms, accident probably plays a very much larger part in the elimination of individuals than competition. To quote Kellogg[10]: "What shall decide, when the big whale opens his mouth in the midst of a shoal of myriads of tiny Copepods floating in the pelagic waters of the Aleutian seas, what Copepods shall disappear forever? Mainly, we may say, the chance of position. A bit more or less of size, or strength, or redness, or yellowness, or irritability, or what not, of form and function, is going to avail little when the water rushes into the yawning throat. Now this chance and this luck are the luck and chance of the law of probabilities; that is, luck and chance capable of being mathematically determined. Given so much ocean, with so many whales swimming about in such and such curves at such and such rates and opening and closing their mouths intermittently at such and such intervals, and just so many shoals of so many million Copepods, these shoals at such and such distances apart, and any mathematical friend will reckon for you the chances any one Copepod individual has at any given moment of being swallowed. But Darwinian variations in the Copepod body will be represented by no function in the mathematician's formula." And Wolff[11] has somewhat humorously called attention to the fact that the fate of millions of tapeworms

10. Darwinism To-day.
11. G. Wolff, Beitrage zur Kritik der Darwin'schen Lehre.

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may hang on a speech made in the Reichstag concerning the inspection or limitation of the importation of meat.

You will have noted that all these objections are in the way of destructive and academic criticsm, seem to be faultfinding, so to speak; and it must be said that for most of the points mentioned, the latter-day exponents of "Darwinismus" have a more or less appropriate reply. Experimental Biology, however, has made certain contributions to the subject that force a re-statement of the original Darwinian position and in the minds of many compel an abandonment of the selection hypothesis as an explanation of the Method of Evolution. Chief among these have been the results of animal and plant breeding. Beginning with Galton and continued by others, the principle of regression has been emphasized. That is, not even by artificial selection can the type be indefinitely moved from its center of stability.

Within the past few years Johannsen[12] has conducted extensive experiments in breeding beans, and Jennings[13] in rearing Paramecium, one of the one-celled microscopic organisms commonly found in stagnant water. The advantage of both of these types is that in the care of the beans the flowers may be self-fertilized, and in the case of the Paramecium reproduction occurs by direct fission of the parent organism into two. In both cases the progeny of any one individual may be kept separate without the introduction of unknown factors through the cross fertilization or mixing of two strains, necessary with most animals and plants. Both these observers found that the progeny of each individual showed a range of variation, which could be plotted in a curve, but that selection from this lot did not alter the curve, i. e., it was impossible to vary the type by selection, for the reason that by something intrinsic in the nature of the race it regressed or reverted to the norm of its derivitive. The progeny of each individual differs from another, and these have been called genotypes or pure lines. The species itself has been made up of numerous genotypes of this kind, which by constant crossing or hybridizing one with another have produced an apparently greater range of variation for the whole group (the phænotype). Now, it is apparent that selection (natural or arti-

12. Johannsen, W. "Uber Erblichkeit in Populationen und in Reinem Linien," 1903.
13. Jennings, H. S. American Naturalist 1909, v. 43, 321 and elsewhere.

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ficial) from the mass of the race can do nothing more than isolate individual pure lines, which are in themselves capable of varying only within narrow limits, and hence incapable of providing that adjustment to a changing environment which brings about the formation of a new species. This is, after all, merely the experimental proof of the conclusion previously reached on a priori grounds, that selection cannot create, but can only modify.

Secondly, whenever a biologist has had an opportunity to study a large series of forms, particularly wherever the rocks have afforded the past history of some one type, like that of the Ammonites, it has been evident that variation as expressed in the succession of forms in time has not been haphazard—now in this direction, now that—but has steadily followed a line of progress. It has, in other words, been *directive* or Orthogenetic variation, and whatever the nature of the *internal perfecting principle* at the bottom of it (about which we know nothing at all), it is certain that in these cases the mechanical explanation of Darwin is too easy, too naive, and does not accord with the facts.

In the third place, Tower has shown in experiments on potato beetles that various sorts of bizarre types, apparently permanent in their heredity, may be produced by the direct action of environmental stimuli, provided the environmental stimulus be applied at a time when the germ cells are maturing and when apparently the germ plasm is relatively unstable. The direct action of the environment in producing new types must be denied, by hypothesis, by thorough-going Darwinians, altho conceded by the Lamarckians.

For all of these phenomena, fundamental and unsettling as they are, we have not a glimmer of understanding or of explanation. Whither, then, shall we head our bark, we who have held so long to the star of Natural Selection? Shall we drift idly on the sea of speculation, or shall we stop rowing? As this is a college rather than a nautical audience, let me vary the figure. Those of you who have watched a foot ball game may often have seen times when the ball was being steadily and uninterruptedly advanced down the field; then all at once there would be a fumble and the ball would be lost. In the scramble no one seemed to know where it was, under the mass of men. When this happens it isn't customary, however, for the players to retire to the side lines and declare the game off.

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Neither do they start all over again. But the referee marks the spot and all line up for a fresh scrimmage.

In attempting to solve the riddle of Evolution, biologists may perhaps have temporarily lost the ball, but they have, by no means, lost the game.

To come again to plain statements, the recent pamphleteers who seem to think that there is no alternative between Darwinism and Genesis[14] may well be counselled to read some of the contributions to evolutionary literature of the past twenty years in order to properly ballast their zeal with facts. These contributions may safely be said to have had no influence whatever in crumbling the foundations of Darwinism. The real attack has come from within and only from those with eyes "single to the truth" like Darwin himself, and who follow the truth as they find it, no matter where it lead them.

A couple of years ago the scientific men of all nations and classes gathered together to celebrate the semi-centennial of the publication of a book, and wherever groups of any size could assemble symposia were held, in which the influence of that book was discussed, the author's views analyzed and compared with present day opinions on the same subjects. Some of the criticisms were laudatory, some were adverse. Well known men, in discussing the same point, frequently took opposite sides, but it never occurred to any one to question the preeminence of that book as a landmark of intellectual progress, something to measure by and to date from. The book was Darwin's "Origin of Species", and it was not without significance that biologists should estimate its worth in such fashion, for it has been my personal experience that outside the ranks of professional scientists, a goodly number of those who unhesitatingly endorse the "Origin of Species" and the doctrines that it stands for, would be quite unable to say whether the work was written in prose or in blank verse.

In conclusion, let me quote Huxley, from an address written in 1880: "History warns us that it is the customary fate of new truths to begin as heresies and to end as superstitions; and, as matters now stand, it is hardly rash to anticipate that in another twenty years the new generation, educated under the influences of

14. Wolff refers to "the episode of Darwinism" and suggests that our attitude toward him should be "as if he had never existed." (Quoted by Kellogg.)

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the present day, will be in danger of accepting the main doctrines of the Origin of Species with as little reflection as so many of our contemporaries twenty years ago rejected them. Against any such consummation let us all devoutly pray; for the scientific spirit is of more value than its products, and irrationally held truths may be more harmful than reasoned errors. Now the essence of the scientific spirit is criticism. It tells us that whenever a doctrine claims our assent we should reply, 'Take it if you can compel it.' The struggle for existence holds as much in the intellectual as in the spiritual world. A theory is a species of thinking and its right to exist is co-extensive with its power of resisting extinction by its rivals."

Honest Biologists will tell you today that Darwin's hypothesis has proved inadequate to explain all the phenomena that must be explained if it be a universal key to the riddle of evolutionary progress. But that it does explain much that is otherwise inexplicable no one can deny. That it is the most useful tool fashioned by the intellect of man since Lavoisier's generalization of the Conservation of Matter or Newton's "Law" no one will deny either. And if in the progress of knowledge we finally outgrow its use altogether, yet Darwin will continue to stand for all time, second to none among those whose labors have helped to free man from the shackles of superstition and helped him toward that larger freedom of thought which we like to think makes for man's greater happiness and betterment.

NOTE: In addition to the references mentioned in footnotes, the following works are valuable in getting a viewpoint with respect to the modern critical attitude toward the Selection Theory.

HESSE, R.

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DEPARTMENT OF NOTES, REVIEWS, ETC.

It is the purpose, in this department, to present from time to time brief original notes, both of methods of work and of results, by members of the Society. All members are invited to submit such items. In the absence of these there will be given a few brief abstracts of recent work of more general interest to students and teachers. There will be no attempt to make these abstracts exhaustive. They will illustrate progress without attempting to define it, and will thus give to the teacher current illustrations, and to the isolated student suggestions of suitable fields of investigation.—[Editor.]

ON THE ONTOGENY OF CERTAIN INTERESTING INSECT STRUCTURES.

The young student of microscopy who studies carefully the chitinous structures of various Arthropoda will find many most interesting and peculiar formations. These are well worth an effort to understand.

Chitin, in a state of purity, is a white amorphous substance, and is excreted by the cells of the epidermis. It is secreted in a semi-fluid form and hardens rapidly on exposure to the air. Chemically, it is supposed to be expressed by the formula $C_{17}H_{14}NO_{12}$. The chitin is manufactured in the cytoplasm of the cell, probably by specialized plastids analogous to the chloroplasts of plants.

In most cases it is produced in rows or strands of small particles, which are extruded thru the wall of the cell; and upon hardening it forms an encasing mold of the surface on which it hardens.

The extrusion of these cell products in vesicular shaped cell membranes forms the various kinds of scales found on insects,—the strings of particles forming the striations which give these scales their refractive properties.

Thus a single cell may produce branched or plumed scales, or spines of various shapes; and even spines or scales with a sensory function. In this latter instance the cell retains its living contents during adult life.

The cross-section of the chitinous foot-pad on the foot of a grasshopper, as shown in Fig. 1 (Plate V), furnishes us with a very

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complex series of ontogenetic changes in the cells of the chitin organ.

Fig. 2. Diagrammatic sketch of one of the units in the chitinous pad of the grasshopper's foot. The letters correspond in significance with those of Fig. 1.

Originally the cells of the hypodermis (epidermis) were situated on the exterior, as at the point marked A. They were then true epidermis spine cells, each cell being an irregular hexagon and having for its sagitlal outline the form of a short spine with a toothed margin.

The chitin-organ cells (F) then began their excretion of chitin which gradually hardened on exposure to the air. This stage was continued until the section marked B was completed,—the spine cells still being hexagonal, with an opening at each corner of the hexagon.

At the end of the period in which B is formed, a radical change occurs: the six channels at the points of the hexagonal cells now coalesce into a single channel (C) which persists thru a long period of secretion, until the point marked D is reached. At this time another radical change in the process takes place. The secreting cells (F) become entirely detached from the chitinous pad (A-B-C-D), and form a convoluted gland surface which pours its secretion into the space which is formed at E.

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It is presumed that during life the channels (E) remain open, and convey gland products from E to the exterior thru the hexagonal interstices.

The adhesive organ on the pulvillus of a fly's foot is similar in origin to this pad of the grasshopper, with the exception that the serrations on the original epidermal cells (A) are prolonged in minute hairs, many to the cell,—which hairs have a small cup on the end into which the adhesive fluid is exuded.

The pulvillus of the fly's foot is homologous with the foot-pad of the grasshopper,—only in the fly the pad has become pendant and has moved outward until it lies side by side with the terminal pair of pads, which have been metamorphosed into claws for grasping purposes.

The pseudo-tracheal tubes from the tongue of the horse-fly (Tabanidæ), shown in Fig. 3 (Plate II), are another very complicated form of chitin cell formation. They represent both phylogenetic and ontogenetic changes.

The appendages of the insect head are now quite generally considered to be metamorphosed legs, of which each segment of the body originally bore a pair. Under this description and with this homology, would be included the so-called "tongue" of insects.

Fig. 4. Diagram of the cells of the hypodermis of the "tongue" of the Horse-fly, suggesting the ontogenetic origin of the pseudo-trachea.

The two legs from which the tongue is formed were evidently covered with a hypodermal layer of cells, each cell of which bears several spines, much perhaps as on the other side of the leg (at A. Fig. 3).

At first the hypodermal layer of cells is flat, with cells of many spines, as at A, Fig. 4. Later it forms a series of parallel invaginations or furrows into which are turned the spines with their bases projecting outward,—which bases form the peculiar shoulder at the edge of the furrow. These spines lie in the furrow alternately, as at B, Fig. 4, first from one side of the furrow and then from the other.

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As the chitin deposit thickens, the hypodermal gland cells come to lie more and more removed from their original position and form, as at C, Fig. 4, until finally when the structure is finished, as in D, there is no further connection between the cells and their finished skeletal product.

These false tracheal tubes serve for sucking fluids up into a central channel formed between the pair of legs which conveys fluid to the mouth. This lobe of the tongue seems homologous with the foot-pads on the other legs and is probably a compound of several pads, very much modified in function.

In many kinds of flies the space between the furrows is covered with spines, many of which are sensory in function. In some flies the furrows appear to be closed tubes, which bear a striking appearance and much resemble true tracheal tubes. It is only by knowing the ontogeny of these structures that one can judge correctly of their nature.

The microtome work, on which these photographs and studies are based, was done by the late Dr. G. S. Shanks.

E. W. Roberts, *Battle Creek, Mich.*

AN IMPROVED REAGENT STAND.

All users of Bausch & Lomb's reagent stand No. 16342 have no doubt found it one of the best devices for the purpose to be obtained. Some of them, like the writer, may have seen times when it would have been an improvement if the reagent bottles were on a revolving base so that by a slight touch the desired bottle could be brought nearest the operator.

The writer obtained the above result so easily and at such small expense that the following cut and description of the modified reagent stand is submitted, hoping it may prove of interest to others.

Referring to the following cut showing a cross section of the stand: The base, in order to reduce the weight, was recessed 5⅛ inches diameter to a depth ½ inch below the bottom of the recess which received the bell-glass cover.

In order to get the revolving feature, an ordinary ball bearing furniture caster was used by removing the truck and securing the

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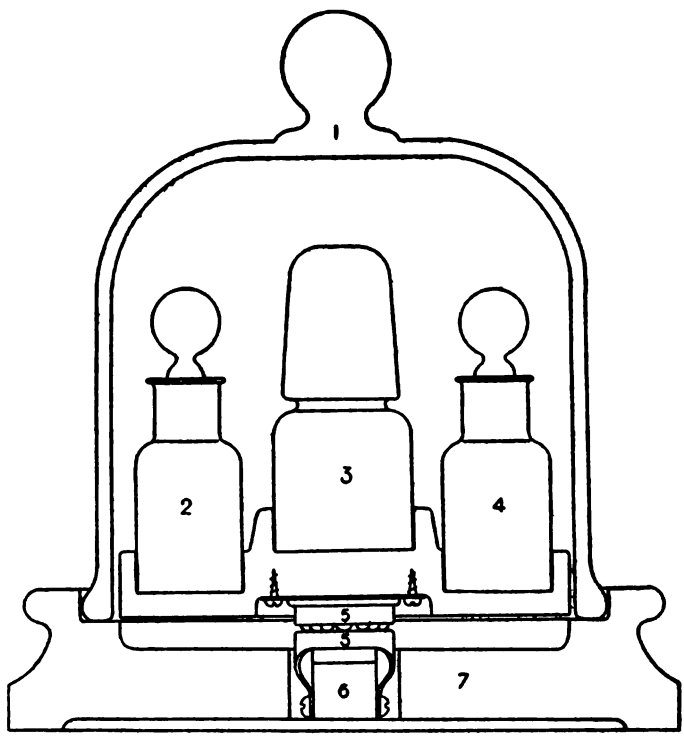
remainder to a wooden plug one and one-quarter inches diameter inserted into the center of the base of the stand as shown.



To the top surface of the caster was secured a piece of well seasoned wood (Turntable) turned 5⅛ inches diameter and 1¼ inches thick, the bottom side being recessed ¼ inch deep to receive the top of the caster, and the top surface recessed with holes of proper diameter and depth to receive the balsam bottle and the seven reagent bottles.

GEO. H. MARR, *Waterville, Me.*

SEND IN YOUR NOTES.

Send in notes of your most successful methods and practise in collecting, cultivating, breeding, and preserving microscopic animals and plants; your best methods of preparing and displaying some difficult or unusual type; specially effective methods of class demonstration; striking pedagogical devices liable to make microscopic work more valuable to students. Indeed, send any unpublished notes of your discoveries which have added zest or efficiency to your own work. (Ed.)

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OBSERVATIONS ON PLASMODIUM OF MYXOMYCETES.

Jahn (Ber. Deutsch. Bot. Gesell, 1911) reports studies on the Myxomycetes, such as *Stemonitis, Trichia,* and *Physarum.* (1) Plasmodia may be observed in formation by drying out the ciliated spore stage, thus forcing them to become encysted. On wetting, these divide. The process may be repeated several times. (2) Certain of the ameboid cells initiate the plasmodium formation, and may devour other surrounding amebæ. (3) Nuclear divisions ensue, the rate of division among them remaining quite uniform, as the number of nuclei is normally even. (4) Ameboid copulation and nuclear union were seen. (5) The plasmodia nuclei possess the 2x number of chromosomes as against the x number in the ameba nuclei. (6) The reduction division is the one immediately preceding the spore formation.

ANIMAL TUMORS AND "CROWN GALL" IN PLANTS.

Dr. Erwin F. Smith in his presidential address before the Botanical Society of America at Washington (also in Circular 85, U. S. Bur. Plant Ind., and in Science Feb. 2, 1912) emphasizes certain most interesting and suggestive resemblances between "crown-gall" in plants and malignant animal tumors. He succeeds in showing that the similarities are not merely superficial and incidental ones. He finds that they agree (1) in being non-granulomatous; (2) in that cells of the organism become a disturbing force, multiplying without reference to the physiological needs of the region; (3) in the general structure of the primary tumor; (4) in the production from these of secondary tumors; (5) in the actual connection by strands of invading tumor cells of the primary tumor with its derivative secondary tumors; (6) in that the form of structure of the secondary tumor tends to be that of the organ in which the primary tumor is found rather than of the organ in which the secondary tumor itself occurs; (7) complete recovery if all the tumor tissue is removed, otherwise growth may continue.

Dr. Smith finds that the crown-gall is accompanied, and caused, by a micro-organism (*Bacterium tumefaciens*) and that it may readily be transferred to healthy plants by innoculation. He also found evidences that this organism produces in fish ulcerous growths similar to animal sarcoma.

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ARTIFICIALLY INDUCED SEGMENTATION OF EGGS OF TOAD.

Bataillon (various papers in Comptes Rendu 1911) has produced segmentation of the eggs of the toad without the male cells. The method involves bathing the eggs in blood, and in puncturing the egg with a needle. He holds that the mere puncture will not serve, but that some foreign body must find its way into the wound. Blood of fish or frog or toad; or the sperms, extract of the spleen or testis will serve to stimulate the nuclear action.

HETEROCHROMOSOMES IN PLANTS.

Tahara (Bot. Mag. Tokyo, 1910) has discovered in *Morus indica,* the wild mulberry, a differentiation among the chromosomes comparable to that earlier discovered among animals. During the early prophase stages in nuclei of the sporophyte, and still more noticeably as the chromosomes enter the equatorial plate, two pairs of the chromosomes are larger than the others. In the spore mother cells (X-generation) there are 14 chromosomes (bivalent), one pair of which shows larger than the rest. This paper opens up a most interesting field for the students of plant cytology, considering the important place which the heterochromosome has in the theory of zoology.

A similar phenomenon is reported by Ishikawa (same journal) for *Ginkgo biloba.*

ANOTHER STEP IN THE STUDY OF CELLS IN VITRO.

Lambert and Harns (J. Exp. Med. Nov. 1911) call attention to the advantage of the *in vitro* method in studying the exact effects of specific cyto-toxins as compared with the complex body conditions. They note the following results: (1) Mouse sarcoma, growing vigorously in plasma of normal rats, is unable to grow in plasma immunized by mouse sarcoma injections; (2) rat sarcoma, which is readily cultivated in normal guinea pigs, will not grow in plasma of guinea pigs which have been previously treated with the rat tissue. He believes that the reason for these failures to grow is the presence of cytotoxins which have developed in these alien plasmas.

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POLYMORPHISM IN ALGAE.

In Proc. Linn. Soc. N. So. Wales (1910), G. I. Playfair reports a piece of work on Desmids, which needs to be done, and might be undertaken profitably even by isolated students, for other groups of algæ also. It requires careful observation over long periods of time. He discovers great polymorphism among the Desmids, as among other algæ; and believes that only about 10 per cent of the species are valid, the other 90 per cent being polymorphic forms of them. The degree of polymorphism and the environmental factors influencing it both need to be studied for numerous algæ.

DISINTEGRATION OF MICRO-ORGANISMS.

J. E. Barnard (Jour. R. M. S. Oct. 1911) describes a mechanical method for disintegrating organic cells and obtaining the protoplasmic contents by rupturing the cell walls. This is done by grinding in a metal vessel, by means of rotating balls pressing against the surface of the vessel. Construction is such as to minimize friction with its resulting heat and disintegration of the metal. No abrasive material is used. The object of the apparatus is to get bacterial proteins or other cell constituents, especially the toxins in the case of those bacteria that retain their toxins in large degree within the cells.

REGENERATION OF BLOOD PLATELETS IN DOGS.

Dake (Jour. Exp. Med. Sept. 1911) gives the following results of a series of experiments: (1) Repeated withdrawal, defibrination, and reinjection of blood in dogs reduces the platelets to a very low percentage of their normal number; (2) at such times there is a tendency to bleed profusely; (3) platelets regenerate very rapidly,—about 1-5 of the total in 24 hours. From these results he believes that the platelets are normally produced rapidly, utilized or disintegrated rapidly, and have a brief life-history.

WHITE CORPUSCLES AND DUCTLESS GLANDS IN TOAD.

H. Mietens (Jena. Zeitschr., 1910) finds that the white blood corpuscles arise, in the embryo of the common toad, (1) from unspecialized blood cells which may also give rise to the colored

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cells; (2) from mesenchyme cells; and (3) from endocardial cells that become freed. In the adult, both white and red cells may arise in the mesenchyme of the liver. According to this writer some of the ductless glands, as thymus and spleen, arise from the entrance and multiplication of migratory cells within the sheaths of certain blood vessels.

THE ADULT OF THE PEARL-PRODUCING PARASITE OF THE OYSTER.

T. Southwell (Ceylon Marine Biological Reports V:1911) believes that he has demonstrated the probability that the adult of the worm, which in the larval stage stimulates the formation of the pearl in the oyster, is *Tetrarhynchus unionifactor* and may occur in the Elasmobranchs that feed upon oysters. The adult worm was found in specimens of fish which had been kept in an enclosure and fed on infected oysters,—whereas similar fish not so fed were destitute of them.

EFFECT OF TESTIS EXTRACT ON FEMALES.

Since the discovery of the role of hormones in the blood and of the influence of the products of sex glands on the development of the secondary sex characters in males, efforts have been made to determine to what extent male characters can be induced in females thru the influence of male hormones.

Geoffrey Smith (Q. T. M. S. 1911) fails to find any evidence that the internal secretions of the testis of the cock, when injected into the female, tends to produce the secondary sexual characters of the male.

SEXUALITY IN SPORES OF MOSSES.

Marchal (Bull. Soc. Roy, Bot. Belg. 1911) says that a diœcious moss (e. g. *Bryum caespiticium*), is really heterosporous, and that half the spores produce protonemata from which male, and half from which female, gametophytes arise exclusively. He claims that this diœcism begins in the tetrad,—two spores from each tetrad producing male, and two female, gametophtes. This suggests the Mendelian segregation of sex characters.

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LONGEVITY OF BACTERIA IN THE PRESENCE OF LACTIC ACID.

Darbois (C. R. Soc. Biol. 1910) finds that *Micrococcus Melitensis,* which is not a particularly hardy species, survives exposure to a lactic ferment in milk as much as 18 days. This suggests that contaminated milk may thus carry infection in products made from it for considerable periods.

CROSSING IN SPIROGYRA.

Andrews (Bull. Tor. Bot. Club, 1911) notes the discovery of conjugation of *Spirogyra crassa* and *Spirogyra communis.* Reciprocal crosses were found, tho usually the protoplasm of *S. communis* moved over into *S. crassa.* It is to be hoped that there may be later studies of the hybrids after the germination of the zygopores, which are said to be normal in appearance.

A RED EUGLENA.

Hardy (Victorian Nat., 1911) describes a new Euglena, which he calls *E. rubra,* from near Melbourne, Victoria. It occurs in the same locality with *E. viridis.* The author gives a full account of its structure, habits, and divergence from *E. viridis.*

EFFECT OF X-RAYS ON SEX CELLS.

Nogier and Regand (Compt. Rendu. Soc. Biol., 1911) report that complete castration and destruction of semen-producing cells in adult cats and dogs is possible, without injury to intermediate tissues, by means of X-rays.

METHODS OF WORK FOR MICROSCOPISTS.

It is desired that this department shall become of real value to the members. To this end the readers are urged to send in brief, yet clear and complete, accounts of successful devices or methods in connection with any department of microscopy. Quite a number of members have expressed a wish for some such clearing house of practical suggestions for the use of student and teacher. (Ed.)

CLEARING LARGE OBJECTS.

O. Schultze recommends the following clearing process to prepare for the examination of somewhat pigmented, or otherwise

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opaque, objects *in toto*. It will clear such objects as tadpoles, worms, etc., so that the internal organs may be studied. Use:—

1 per cent Chromic acid	80 c. c.
Eau de Javelle	5 c. c.
Potash	10 drops

This fixes, depigments, and clears.

SEXUAL FUSIONS IN YEAST.

A. Guilliermond (Compt. Rendu, 1911) has observed fusion of yeast cells preliminary to the formation of ascospores. He believes that he has established that the common parthenogenetic formation of asci marks a retrogression from the copulating condition, such as is well known in species of *Saprolegnia*.

PHOTO-MICROGRAPHY.

In a little hand-book entitled "Elementary Photo-Micrography" Mr. Walter Bagshaw undertakes to make easy, or at least pleasant and hopeful, the way of the beginner who cannot take the time, nor undergo the expense, necessary to operate an elaborate and costly apparatus. The chief excellence of the book consists in its simple direct style; in its avoidance of unnecessary technical details, however interesting; in its common-sense appliances and devices. By means of the book any worker with the microscope, who has knowledge of photography, will be able at once to combine the two knowledges in such a way as to make a permanent record of the things that interest him.

The various chapters deal with such subjects as these: How to make a simple microscopic outfit; Photo-Micrography without a microscope; Illumination; Focussing, Measuring amplification; Exposure; Requisites for development—and rules for developing, fixing, clearing, intensification, reduction, printing, etc.; Lantern slide making. There are also appendices containing information useful to the operator.

Elementary Photo-Micrography, by Walter Bagshaw, with 103 pages and illustrations. Second Edition. 2/6 net. Iliffe & Sons, Lim., London.

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CENTENARY OF THE ACADEMY OF NATURAL SCIENCES.

The Society has received an invitation to be represented at the celebration of the centenary anniversary of the founding of the Academy of Natural Sciences of Philadelphia, on March nineteenth to twenty-first next. Mr. Edward Pennock, second vice-president of the American Microscopical Society, and Dr. H. L. Shantz, of Bureau of Plant Industry, Washington, D. C., have been named as delegates representing this society.

A NEW ROTARY MICROTOME.

The Spencer Lens Company have recently came out with a new rotary microtome which obviates the difficulties inherent in the old rotary microtomes, and provides for cutting sections of uniform and even thickness with the same accuracy and delicacy that have heretofore been obtained only on the best sliding microtomes. Any person interested in such a microtome would do well to write the Spencer Lens Co. for circular describing this instrument.

AN EARLY LETTER OF R. B. TOLLES.

In the light of the recent action of the Executive Committee of the American Microscopical Society to retain the administration of the Spencer-Tolles memorial fund within the Society and to begin using the income of the fund as soon as practicable as a memorial, the following letter, written by Mr. Tolles when he was twenty years of age, will prove interesting. It is furnished by the wife of the late Charles X. Dalton.

Canastota, June 30, '44.

My Dear Grandfather:

I handed a letter to Father while he was here to yourself, stating that I hoped to be in Conn. by this present time. You may not yet have received that letter; I now write for that reason and because I do not incur the expense of postage. Father then (when here) intended to be in Conn. soon to see you and hand you the letter. I imagine he has not gone as yet.

I had every reason to suppose when I borrowed the money of you last fall that I should be able to return it by the last spring past. The reason that I was and am not at present is, that I have not rec'd one half of my wages (at $2 per week, and board and clothes out of that). The arrangement I made with Mr. Spencer was that there should be no stated times of payments, but rather at his convenience, as his orders are large and time inter-

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venes between them. But I did not suppose it would be so inconveniently that way, as in fact. However, it will be right at the end of the year, next Oct., and I do not suppose it likely that I will be able to pay the $10 before; but then it *shall* come with interest. The most unpleasant part of the matter is that I am not able to do anything for my sisters, but I *shall* do more after the time mentioned. I am in a situation to learn a good deal that will be profitable to me hereafter, in a *dollar and cents* view, too, and therefore I take up with a good deal of inconvenience and some *chagrin,* which is better by the way, than with a tinsel character to be an adventurer *upon* the world; for it *ends* well.

We have been making Daguerreotype Instruments for taking portraits. I am now making myself one. I may have such word from New York as to enable me to take it east and finally sell it in N. Y. or otherwheres. I suppose we make better instruments of this kind than are made *otherwheres.* This of mine will be worth $15 to $25. I have thought some of going abroad and taking portraits myself, but that is somewhat slow. I wish much to see you and more especially to hear from you by *letter* that you enjoy *health,* etc.

Your affectionate Grandson,

R. B. Tolles.

Father expects to make sale of an improvement on the Rail Road Cos. for the prevention of accidents from the "Snake heads" as they call them (a loosend rail bent up at the end, a frequent thing). Mr. Spencer, my employer, has taken the negotiations into his hands, and it is quite probable that it may result favorably. R. B. T.

A NEW MEDIUM FOR DARK-FIELD OBSERVATION—"THE LEITZ CONCENTRIC REFLECTING CONDENSER."

This improved Reflecting Condenser, the invention of Dr. Felix Jentzsch,* of the scientific department of E. Leitz, Wetzlar, is adapted for observation under dark-ground illumination, and more especially for bringing into view living and unstained bacteria.

Every Microscopist familiar with the darkground illuminating apparatus has certainly realized the importance of such an instrument, and it undoubtedly will interest him to learn that E. Leitz has now introduced a new type of Darkfield Condenser, the so-called "Concentric Reflecting Condenser."

The object of this method is to establish an extremely vivid contrast between the intensely illuminated bacteria and the dark back-ground. To obtain such a dark back-ground it is essential

*Physikalische Zeitschrift, Vol. 11, pp. 993-1000, 1910, and Verhandlungen der deutschen Physikalischen Gesellschaft, Vol. 12, pp. 975-991, 1910. Paper read on the 22 Sept., 1910, before the 82nd German Congress of Science and Medicine at Konigsberg.

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that none of the rays which go to illuminate the object should pass directly into the objective, and to secure an intense illumination of the object it is necessary to employ a very powerful source of light and to form a perfectly defined image of the radiant within the preparation itself.

Both requirements are satisfied by the presence of two reflecting surfaces, one convex, the other concave, both being arranged as indicated in Fig. 1. Since the rays are brought to a focus by reflection only, whilst refraction does not enter into the process, there is no chromatic dispersion. The spherical aberration, on the other hand, is reduced to an *insignificant amount* and does not within the entire zone which enters into consideration exceed 0.7 per mile or 0.0007 of the focal length of the system, i. e., in the condenser as

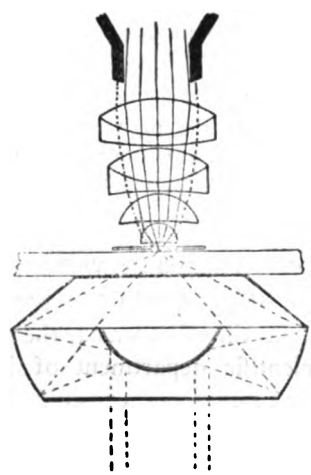

Fig. 1.

actually made the whole of the rays which enter the condenser in a direction parallel to the axis are brought to a focus accurately within 2.3 micron. *This entitles the Concentric Condenser to be looked upon as the most perfectly corrected optical combination which is in existence at the present time,* and it represents the closest approach to an ideally perfect aplanatic system which has yet been produced.

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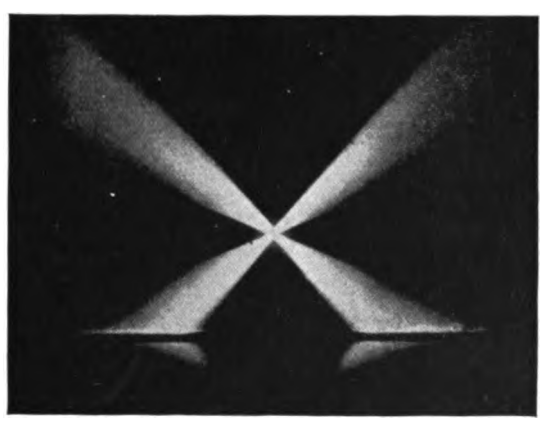

Fig. 2.

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This interesting result has been accomplished by the use of concentric zones of spheres, the radii of which are in the ratio of 1:226. From Fig. 2, which reproduces a photo-micrograph obtained with the aid of fluorescent uranium glass, it will be seen how very nearly the actual path of the rays conform to the theoretical conditions.

The close approach to mathematical precision with which the rays are brought to a focus renders it very essential that the condenser should be accurately centered and carefully focussed. The optical system is accordingly mounted in a cell which may be slipped into the substage collar of the microscope stand, in the place of the ordinary condenser: it has, however, in addition a special centering device within the cell. To obtain an accurate focus the object slide should have a definite thickness, up to 1 mm. The condenser is focussed with the aid of the rack and pinion of the substage.

A NEW MICROSCOPIC ALGA FOR AMERICA.

E. N. Transeau (Trans. Ill. Acad. Sci. 1911) reports the finding of the rare alga, Gloeotaenium, in Illinois. As found the alga appears in 2- or 4-celled families, and is a striking microscopic type. Its occurrence is remarkably limited, being found only in an area of about two square meters in the corner of a small artificial pond formed by excavating clay in a tile-yard. Before this it has been found only in Trinidad in the Western hemisphere.

SEASONAL SUCCESSION AMONG POND ANIMALS.

W. C. Allee (Trans. Ill. Acad. Sci. 1911) reports a piece of work the like of which should be done with care in many parts of the country. He has made a study of the seasonal succession of animals in old forest ponds at the south end of Lake Michigan. Such a study demands regular collections of materials during the year; a record of all observable physical conditions, as temperature, amount of water, chemical and other character of the water, amount and character of organic food, etc.; an identification of the species and an estimate of the absolute and relative frequency of each; and finally an analysis of the results in such a way as to reach the laws and the causal factors of the successions. Such work lends itself in an excellent way to the possibilities of the isolated

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student with the microscope, both with plants and animals, and in the interrelations of plants and animals. Mr. Allee summarizes his results as follows:

1. The phenomena of seasonal succession hold, both in regard to succession of species and to the number of individuals in a species.

2. In numbers the crustaceans are dominant in Spring and Autumn with *Asellus communis* as the dominant species; the Mollusks are dominant in mid-summer, with *Lymnaea reflexa* as the dominant species.

3. The most crowded habitat in the spring is the bottom along the margin of the ponds; in mid-summer, at the surface and in the deepest water; and in the autumn, near the green water plants.

4. The range of animals is more restricted during their breeding season.

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NECROLOGY

Mr. Charles F. Cox, for many years a member of the American Microscopical Society, died in New York City recently. He was a Fellow of the American Association, of the Royal Microscopical Society, of the New York Academy, and a member of numerous other scientific societies. As treasurer of the New York Academy and of the New York Botanical Garden, and as a member of the Council or Board of Directors of other organizations, Mr. Cox contributed largely from a rich and successful business experience to the advancement of scientific work in this country. He was primarily a railroad man serving in important positions some of the greatest and most successful corporations of the United States; nevertheless he found time to devote to scientific studies. His book on Protoplasm and Life was his largest contribution to scientific literature, but numerous smaller papers and contributions presented at meetings of the scientific societies evince at once his interest in and capacity for scientific study. His work was done primarily in the microscopical structure of plant and animals and the fundamental relations of these to the theory of evolution.

Mr. Cox' career is a splendid example of that contribution to scientific advancement common in the old world, and especially in England, but unfortunately rare on this continent. Science can ill afford to lose such services and we may hope that the example of such a life will be a stimulus to pointing out one way in which investigation may be effectively furthered by those who are not primarily devoted to it.

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Announcement of the death of the following members of the American Microscopical Society has been received.

Robert Brown, Life Member.

James Farwell Cowee, '11.

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PROCEEDINGS
of the American Microscopical Society

MINUTES OF THE WASHINGTON MEETING.

The Society was called to order by Vice President Elrod at 3:30 p. m. Dec. 27, 1911.

The Executive Committee recommended for passage at this meeting the proposed amendment to the constitution, making Article VII read as follows:

The initiation fee shall be $3, and the dues shall be $2 annually, payable in advance. But any person duly elected may upon payment of $50 at one time, or in installments within the same year, become a life member entitled to all the privileges of membership, but exempt from further dues and fees. All life membership fees shall become part of the Spencer-Tolles Fund, but during the life of such member his dues shall be paid out of the income of said fund. A list of all life members and of all persons or bodies who have made donations to the Spencer-Tolles Fund in sums of $50 or over, shall be printed in every issue of the *Transactions*. The income of said fund shall be used exclusively for the encouragement and support of original investigations within the scope and purpose of this Society. The principal of the fund shall be kept inviolate; *provided, however, that nothing in this constitution shall prevent the Executive Committee at any regular meeting from transferring the Spencer-Tolles Fund to a University, or other incorporated institution for original research, under such conditions as shall safeguard the permanence of the Fund, and its application to the general purpose for which it was intended; such power to be vested in the Executive Committee only after securing, and in obedience to, the expressed will of a majority of the constitutional members of the American Microscopical Society, or after the constitutional failure of said Society.*

This report was accepted and the proposed amendment unanimously supported.

Owing to the fact that only one session was contemplated, By-laws V and VI were suspended. The meeting, as a committee of the whole, nominated the following officers:

President: Professor F. D. Heald, University of Texas.

First V. Pres.: Professor F. Creighton Wellman, Tulane University.

Second V. Pres.: Mr. Edward Pennock, Philadelphia, Pa.

Custodian: Mr. Magnus Pflaum, Meadville, Pa.

Elective Members of Executive Committee: Professor A. M. Reese, University of West Va.; Professor F. C. Waite, Western Reserve University; Professor W. F. Mercer, Ohio University (Athens).

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Members of the Council of the American Association: Prof. T. W. Galloway, James Millikin University; Dr. Brayton H. Ransom, Bureau Animal Industry, Washington.

To fill vacancy in Spencer-Tolles Committee: Professor S. H. Gage, Cornell University.

The Society instructed the Secretary to cast the ballot for these nominees.

The reports of the Custodian and Treasurer for 1911 were read and referred to an auditing committee comsisting of Professor H. B. Ward, Professor T. J. Burrill, and Mr. P. A. Lehenbauer.

The President and Secretary were appointed a committee to approve the minutes for publication.

Society adjourned.

MORTON J. ELROD, *President.*
T. W. GALLOWAY, *Secretary.*

FINANCIAL STANDING

The secretary is glad to be able at this time to publish the financial standing of the Society to the beginning of the present year. This includes the reports of the treasurers for a period of 5 years. The report of Treasurer J. C. Smith was made promptly at the close of his term of office, and was audited and approved shortly afterward. Its tardy publication is in no way chargeable to Mr. Smith, and is an all too poor recognition of his accuracy and painstaking service to the Society.

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CUSTODIAN'S REPORT FOR YEAR ENDING DEC. 20, 1911

Spencer-Tolles Fund

Reported at Minneapolis Meeting, 1910		$3,151.15
Dividends received, 1911	$191.58	
Office expense returned	19.43	211.01
		$3,362.16
Less dues of Life Members		10.00
Total invested		$3,352.16
Net increase during year		$ 201.01

Grand Totals

All contributions to date		$ 696.27
All sales of Proceedings		625.73
All Life Memberships		250.00
All interest and dividends		1,912.16
		$3,484.16
Less:		
All Grants	$100.00	
All Life Membership dues	32.00	132.00
		$3,352.16

Life members and contributors of $50.00 and over:—John Aspinwall, Robert Brown, J. Stanford Brown, Henry B. Duncanson, A. H. Elliott, John Hately, Iron City Microscopical Society, and Troy Scientific Association.

MAGNUS PFLAUM,
Custodian.

We the undersigned Committee hereby certify that we have carefully examined the foregoing account, compared the same with vouchers and find it to correspond and correct.

HENRY B. WARD,
T. J. BURRILL,
P. A. LEHENBAUER,
Auditing Committee.

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REPORT OF J. C. SMITH, TREASURER OF THE AMERICAN MICROSCOPICAL SOCIETY SUMMARY FOR 1906-1907

On hand		$129.45
Dr.:—To Membership Dues:		
1903	$ 2.00	
1904	6.00	
1905	20.00	
1906	64.00	
1907	278.00	
1908	12.00	382.00
To admission fees		21.00
To subscribers Vol. XXVII		6.00
To advertisers Vol. XXVI	8.00	
To advertisers Vol. XXVII	108.25	116.25
		$654.70

Credit:		
By postage, stationery and printing—Secretary	$30.62	
By postage and stationery—Treasurer	18.75	$ 49.37
By expressage—Secretary	36.45	
By expressage—Treasurer	1.75	38.20
By typewriting—Secretary		17.75
By Sundries—Secretary		4.68
By R. R. fare to meeting as by appropriation—Secretary		25.00
By Bank charges for collecting checks—Treasurer		2.50
By plates, Vol. XXVII		43.63
By printing, Vol. XXVII		318.23
By Balance on hand		155.43
		$654.70

Checked and found to correspond with books and vouchers.

DAVID L. ZOOK,
HENRY B. WARD.

March 18, 1908.

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SUMMARY OF ACCOUNT OF THE AMERICAN MICROSCOPICAL SOCIETY DURING THE INCUMBENCY OF DAVID L. ZOOK, TREASURER

		Dr.
From J. C. Smith, former Treasurer:		
Check	$50.00	
Check	90.00	
Check	9.37	$149.37
Membership dues		562.76
Admission fees		24.00
Subscribers to Vol. XXVI	2.00	
Subscribers to Vol. XXVII	38.00	
Subscribers to Vol. XXVIII	6.00	46.00
		$782.13

	Cr.
Stationery for Secretary and Treasurer	$ 19.95
Postage used by Secretary and Treasurer	23.25
Exchange on remittances by members	2.75
Multigraphing for Secretary	39.20
Printing and plates	513.83
Check to American Microscopical Society to balance	183.15
	$782.13

We the undersigned Auditing Committee certify that we have examined the above account and find it to correspond to the books and vouchers submitted therewith.

Jan. 27, 1911.

T. W. Galloway,
T. L. Hankinson,
Henry B. Ward.

[Two vouchers, totaling $6.06, put into the hands of the auditing committee by Mr. Zook, satisfactorily account for the apparent discrepancy between the balance of the preceding year and the cash at the opening of his account.]

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REPORT OF T. L. HANKINSON, TREASURER OF THE AMERICAN MICROSCOPICAL SOCIETY

For the period from July 21, 1910, to December 21, 1911.

	Dr.
To former Treasurer, D. L. Zook, as balance due the Society	$ 183.15
To dues of old members	321.75
To initiation fees and dues of new members	410.00
To subscriptions for Vol. XXX of Transactions	58.00
To sale of sets of Transactions	100.00
To other sales of Transactions	63.50
To advertisers in Vol. XXIX, No. 2, and Vol. XXX, Nos. 1, 2 and 3	193.10
To J. S. Foote to help defray the expenses of publishing his paper in Vol. XXX	150.00
To contribution for making a plate	3.00
Total receipts to Dec. 21, 1911	$1,482.50
	Cr.
By printing of five quarterly numbers of the Transactions, Vol. XXIX, No. 2, and Vol. XXX	$ 963.33
By engraving plates for Transactions	90.93
By postage of Secretary and mailing Transactions	142.08
By expressage of Secretary	16.35
By postage of Treasurer	25.03
By printing of Circular letters	12.22
By printing of advertising matter	61.24
By stationery	17.00
By stenography and other office expenses of the Secretary	41.45
By the same for the Custodian	23.43
By the same for the Treasurer	.75
By legal services involved in incorporating the Society	18.20
By sundry expenses	3.00
By balance on hand Dec. 21, 1911	67.49
Total	$1,482.50

Examined and found correct, with proper vouchers for expenditures.

F. J. Burrill,
Henry B. Ward,
P. A. Lehenbauer,
Auditing Committee.

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ORGANIZED 1878 INCORPORATED 1891

APRIL
1912

VOLUME XXXI No. 2

TRANSACTIONS

OF THE

AMERICAN MICROSCOPICAL SOCIETY

PUBLISHED QUARTERLY BY THE

AMERICAN MICROSCOPICAL SOCIETY
DECATUR, ILLINOIS

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EDITED BY THE SECRETARY

VOLUME XXXI

NUMBER TWO

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1912

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First Vice President: F. Creighton Wellman, M. D....New Orleans, La.
Second Vice President: Edward Pennock.....Philadelphia, Pa.
Secretary: T. W. Galloway.....Decatur, Ill.
Treasurer: T. L. Hankinson.....Charleston, Ill.
Custodian: Magnus Pflaum.....Meadville, Pa.

ELECTIVE MEMBERS OF THE EXECUTIVE COMMITTEE

A. M. Reese.....Morgantown, West Va.
F. C. Waite.....Cleveland, Ohio
W. F. Mercer.....Athens, Ohio

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Past Presidents still retaining membership in the Society

R. H. Ward, M.D., F.R.M.S., of Troy, N. Y.,
at Indianapolis, Ind., 1878, and at Buffalo, N. Y., 1879.
J. D. Hyatt, of New Rochelle, N. Y.,
at Columbus, Ohio, 1881.
Albert McCalla, Ph.D., of Chicago, Ill.
at Chicago, Ill., 1883
T. J. Burrill, Ph.D., of Urbana, Ill.,
at Chautauqua, N. Y., 1886, and at Buffalo, N. Y., 1904.
Geo. E. Fell, M.D., F.R.M.S., of Buffalo, N. Y.,
at Detroit, Mich., 1890.
Marshall D. Ewell, M.D., of Chicago, Ill.,
at Rochester, N. Y., 1892, and at Boston, Mass., 1907.
Simon Henry Gage, B.S., of Ithaca, N. Y.,
at Ithaca, N. Y., 1895 and 1906.
A. Clifford Mercer, M.D., F.R.M.S., of Syracuse, N. Y.,
at Pittsburg, Pa., 1896.
A. M. Bleile, M.D., of Columbus, Ohio,
at New York City, 1900.
C. H. Eigenmann, Ph.D., of Bloomington, Ind.,
at Denver, Colo., 1901.
Charles E. Bessey, LL.D., of Lincoln, Neb.,
at Pittsburg, Pa., 1902.
E. A. Birge, LL.D., of Madison, Wis.,
at Winona Lake, Ind., 1903.
Henry B. Ward, A.M., Ph.D., of Urbana, Ill.,
at Sandusky, Ohio, 1905.
Herbert Osborn, M.S., of Columbus, Ohio,
at Minneapolis, Minn. 1910
A. E. Hertzler, M.D., of Kansas City, Mo.,
at Washington, D. C., 1911

The Society does not hold itself responsible for the opinions expressed by members in its published *Transactions* unless endorsed by a special vote

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TRANSACTIONS
OF
American Microscopical Society
(Published in Quarterly Installments)

Vol. XXXI APRIL, 1912 No. 2

THE STRUCTURE AND DEVELOPMENT OF THE COLONY IN GONIUM

By R. A. Harper

Gonium, a simple coenobic plant growing in all our fresh waters and becoming very abundant when conditions are favorable, is an interesting type which illustrates in very simple terms a close approximation to a pure mosaic development. The plant is a simple plate-shaped colony consisting of four, eight, or sixteen cells. The arrangement of these cells is strikingly uniform in the sixteen celled colony and in this respect it is in marked contrast with such forms as the water net. There are no structural variations in Gonium corresponding to the various shaped meshes with from three to six or seven sides which we find in the water net, and as we shall see this relative fixity of type is doubtless correlated with the method of formation of the colonies by a definitely specified series of cell divisions. In its method of development Gonium thus affords an interesting type for comparison with other coenobic plants in which the colonies are formed by the spontaneous aggregation of free swimming zoospores. The forms I have studied seem to agree in all essential respects with the description of the widespread species Gonium pectorale, Müll. I have found it in aquarium jars at Madison and in open pools at Berkeley, Calif. The figures and micro-photographs here given are all from the Californian material.

The structure and development of the flat plate-shaped colonies of Gonium and their relationship to other members of the volvox series have been carefully described by many of the earlier students of the algae (1, 3, 6, 16). The morphogenetic processes by which

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the solid and hollow globular colonies of Pandorina and Eudorina and the plate-shaped colonies of Gonium and the later discovered Platydorina are developed early attracted attention and the order of cell division and the cell lineage have been accurately worked out.[8]

In my material I do not find that the third divisions tend to be radial, as is described for Eudorina and as Al. Braun[1] thought they must be for Gonium. Cohn's[3] figures of the eight celled colonies whose correctness Braun doubted are good representations of forms, which I find quite commonly. The very young eight celled stage consists simply of two rows of cells and is quite unlike that described for Eudorina. The figures of Bütchli[2] and Migula[14] for the sixteen celled stage are quite inadequate as compared with the earlier one of Cohn.[3] They fail to show the form of the cells accurately and give no correct indication of the apparent difference in size between the central and peripheral cells. They also fail to show that the middle cell on each side is somewhat drawn back toward the center as was noted by Müller[16], Cohn[3] and Al. Braun[1], Oltmann's[17] figure taken from Migula is incorrect in all these particulars. Braun[1] regards the colony as consisting of three concentric series of cells, four, four and eight, thus emphasizing the fact that four of the outer twelve cells are out of alignment with the other eight.

Microphotographs of colonies in a stage of vigorous and rapid growth such as are reproduced in figures 4 to 6 show that the sixteen cells form a square with its corners truncated, giving it a somewhat octagonal outline with a slight depression in the middle of each side. The cells are ovoid or pear shaped (Fig. 19) and bear two cilia at the narrowed end. Part of the cilia are shown in the eight celled colony (Fig. 17). By means of these cilia the organism moves through the water flatwise so that it presents its edge view when observed from above under the microscope. Such an edge view of an eight celled colony is shown in figure 19, and we observe that the cells are noticeably longer than they are wide. The long axis of the cells in the outer row is inclined outward so that the cilia of these cells do not point straight ahead, but obliquely forward.

As the colony swims it rotates edgewise. This mode of locomotion seems extremely awkward since the colony thus offers the greatest resistance to the water. The arrangement of the cells in two series, with four in the interior and twelve in the periphery, is

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correlated with the presence of the large square intercellular space, which is an almost universal characteristic of the colonies. It is not impossible that the opening so formed has some significance in maintaining the equilibrium of the colony as it moves through the water. The water which is to be displaced does not necessarily all have to flow around the edges of the colony; a portion may pass directly through the opening in the middle and doubtless this favors steadiness of movement.

It has been claimed that the whole colony is imbedded in a gelatinous secretion which is so abundant as to fill all the intercellular spaces, including the central square Migula[14] finds evidence of the thickness of this gelatinous envelope in the observation that the motion of the cilia is limited to the outer one-half or two-thirds of their length. I have not been able to convince myself of the presence of any such abundance of jelly about the colonies in my material. The cell walls are gelatinous and I have frequently observed the motion of the peripheral portion of a cilium while the basal portion remains quiet as if held in some way. The same cilium may, however, a few moments later bend freely from its base. Such observations can be readily made on mature colonies whose cells are dividing. The ciliary motion becomes very weak at this time, as will be noted below. Moore and Goodspeed[15] report that the entire cilium may take part in the stroke, though usually only the peripheral one-half or one-third is used. Of course, the amount of jelly secreted may vary under different environmental conditions.

The most important characteristics of the colony as a whole are to be found in the space-relations between the cells. These relations are on the whole strikingly constant and constitute the fundamental structural features of the plant. If we examine the interrelations of the cells of the colony beginning at either corner in the outer row we find, counting the points of contact of each cell with its neighbor, that we have the simple series, 3, 3, 4, repeated four times (See Figs. 1 to 6). The pairs of cells that make the corners of the square are each in contact with only three cells while the middle cell of the side, which is in the slight depression, is just as regularly in contact with four. Each of the four interior cells is in contact with six of its sister cells and these simple relations bring with them an arrangement of the cell walls involving the formation

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of the series of curves which Cohn long ago observed and figured and which come out very clearly when the colony is photographed a little out of focus, as shown in figure 13. We see from this that each of the four inner cells is in reality an inequilateral hexagon, that side which is adjacent to the central square being a little longer than the others. The walls of the cells, as the photograph shows, form four sets of parallel curves. The intercellular spaces are in the same fashion shown to be triangles with somewhat unequal sides, showing at once that the cells are arranged as compactly as possible. All of these structural characteristics we see at a glance are just those which would obtain in any system of spherical liquid or semi-liquid globules which are placed in two such series, that is, twelve about four, assuming also a tendency to the greatest possible compactness. The details of the organization of the colony are in accord with the principle of least surfaces, limited by the method of division by which the cells were produced. Every semi-fluid droplet of protoplasm has rounded itself up in cross section as perfectly as is consistent with its adhesion to and pressure from the adjacent droplets.

If we put together a series of equal circles arranged in this fashion we shall find that the four inner circles will not be in contact either with each other (text Fig. 1) or with certain of the peripheral cells (text, Fig. 2). To bring into contact the whole series of cells as we find them in the Gonium colonies the diameters of the inner

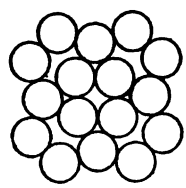

Fig. 1

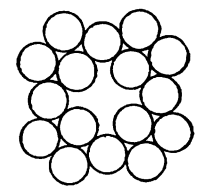

Fig. 2

cells must be increased relatively to those of the outer series. This is apparently accomplished in Gonium by the flattening of the inner cells and by lateral compression of each of the cells in the outer series. This lateral compression of the peripheral cells is especially conspicuous in the young colonies, where the outer cells are frequently (Figs. 1-6) quite oblong.

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We have thus a plant of definite form with a specific arrangement of its constituent parts which is strikingly uniform and whose cells show in certain respects the adhesiveness and surface tensions of colloidal droplets of protoplasm. That the cells have also an internal organization is, however, shown by their pear shaped form and the slightly flaring position of the peripheral series (Fig. 19). The constancy in structural features in Gonium as compared with Hydrodictyon is as noted above rather striking and is doubtless due to the mosaic type of development here present.

The only modification in the cell relations which can be regarded as at all normal is that in which the central intercellular square is omitted, two of the four cells of the inner series being brought together so that they are in contact, the other two being proportionately separated. This generally leads to a change of form of the whole colony, in some cases giving it a somewhat rhomboidal outline (Fig. 11). In the case shown in figure 12 the absence of the intercellular square in the center has been compensated in a sense by the formation of another intercellular square at one corner between the inner and outer series of cells. The colony has thus bcome more nearly square like the ordinary type. These cases with rhomboidal central group are rather rare, so few as to make a fraction of one per cent of the colonies to be observed under normal conditions. In them the greater compactness of the central group leads to a correspondingly increased crowding in the outer series. This may lead to the crowding of one cell out of the plane of the others so that it overlaps two or the displaced cell may come to lie squarely in front of or behind its neighbor. How the cilia are placed in such a case I have not been able to determine. I have never seen the sixteen cells arranged to form a perfect rhomboid. The evidence is clear that the colony is in a state of unstable equilibrium owing to the presence of twelve cells in the peripheral series in the space which would be more naturally filled by ten, as shown in text figure 6.

The figures 14 and 15 illustrate divergences from type which may plainly be classified as pathological or monstrous. Figure 15, for example, shows a colony with sixteen cells in a totally aberrant arrangement. This was the only case of the sort which I have observed. Cases in which one or more of the cells have died or have

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been broken out of the colony in some fashion, are much more common. Such a case is illustrated in figure 14. In such cases the colony shows no tendency to regenerate the missing cells nor to modify its form so as to produce a symmetrical outline. Colonies frequently split in two. This process is shown going on in figure 16. The result is two colonies of eight. Such colonies show no power of regeneration, but they may live and reproduce themselves in an entirely normal fashion. They are to be distinguished from colonies of eight cells formed in ordinary reproduction. Their shape is different, as will be noted.

We may turn now to the problem of the reproduction of the plant in order to determine the method by which such a sixteen celled colony is produced in ontogeny. The cells of the colony are all capable of vegetative reproduction and each one, as a rule, produces a new sixteen celled plate. Division occurs commonly at night from ten to twelve P. M., and the new colonies are set free from the parent cells by the following morning. The general behavior of the plant in these respects is analogous to that of Pandorina, and other related forms. One can watch the process of division readily under the microscope. The colonies generally continue to move about until the division has reached an advanced stage in each cell, but they become very sluggish and can be readily followed. It is impossible, however, in the case of the sixteen celled colonies to obtain satisfactory photographs of these division stages. The connection between the cells apparently becomes very loose. The walls gelatinize and the intercellular connections are broken. As a result the colony becomes warped in various fashions and it is impossible to get any large area of it in a single focus. Figure 10 shows about half of a colony in which the cells are beginning to divide. The colony was sc warped that the other half was badly out of focus. In cell *a* division is just beginning; in cell *b* the first division is complete. Cell c has divided twice and three daughter cells show in the negative, though they have not been brought out in the reproduction. It is obvious at once that the planes of division of the different cells of the colony show no orientation with reference to each other or to the plane of the parent colony. In the case of the four celled colonies conditions are more favorable in this respect and I have obtained a photograph showing the first division of

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all four of the cells in such a colony. This is shown in figure 22. Division does not begin in all of the cells simultaneously and it progresses quite irregularly, after it has once begun. Here again it is evident that the plane of division is independently determined in each cell.

After the cells are all in division while the motion of the cilia continues weakly the colony may become lodged in such fashion as not to move further, and under these conditions it is easy to make camĕra lucida sketches of the entire sixteen cells of the colony, showing the stage of division which each cell has reached. Text figures 3, 4, and 5 show three successive stages in the reproduction

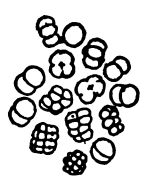

Fig. 3

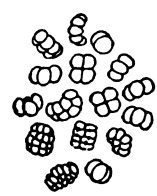

Fig. 4

Fig. 5

of the same colony, separated from each other by intervals of about thirty to forty minutes. The drawings were made with camera lucida between ten and eleven thirty p. m. A glance at the first of these sketches shows at once that the planes of division are different for the different cells. The first division may lie at almost any angle to the plane of the colony and in almost any direction from tangential to radial. It is observed at once that the form of the whole has no dominating influence on the orientation of the division planes, although it is entirely conceivable that such influence should be exerted here, if anywhere, since the cells have been in contact with each other and there is every opportunity for cellular interaction. There is no evidence either of any general form—regulating principle at work. Each cell is apparently self-determined as to the plane of its division, that is the plane of division is determined by cellular organization as contrasted with any assumed heredity of form for the whole organism. When once the first division is begun, however, the plane of the future colony is fixed. A glance at the figures shows at once that the subsequent divisions follow the principle of rectangular intersection, the spindle figures, which may

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be assumed to be present here as in other algae, always lying in the same plane. Each successive plane of division tends to cut that of the preceding division at right angles. No one would question that this is a phenomenon of cellular behavior and is due to the organization of the cell itself, and it works out to produce, as we shall see, a many celled colony of perfectly definite form and organization which is also doubtless fairly adaptive.

The four celled stage consists of equal quadrants which tend at once to round up, leaving a four sided intercellular space between them in the middle. As noted, the colony is already under pressure from the gelatinous cell wall which swells at this stage and forms an envelope which is in contact with the cell mass, although it is so transparent that it does not come out in the photographs. The position of the cells as formed is unstable and this pressure is sufficient in many cases to lead to a slight displacement of the four cells at once, especially as the movement of the cilia tends also to produce unequal strains in the whole mass and thus to lead to readjustments so as to produce the greatest possible compactness. The displacement may go so far as to form a markedly rhomboidal instead of a square group. This condition is shown in a number of young colonies in text figures 3 and 4. It may perpetuate itself throughout the whole life of the colony (Figs. 11 and 12) or it may apparently disappear again later under the conditions of surface tension that develop as the colony grows. It consists in the familiar phenomenon of the separation of two of the cells and the approximation of the other two so that they become slightly flattened on each other in the central region. The next division is at right angles to the second and we thus get a group of eight cells arranged in two rows of four each. This is an interesting stage and is shown in its various appearances in several of the young colonies (text figures 3, 4, and 5). If the colony is under favorable conditions the division may stop at this stage. The cells seem healthy, however, and may grow to normal size as an eight-celled colony (Figs. 17-20) which, however, bears no resemblance in the arrangement of its cells to the normal sixteen-celled colony. I find no tendency whatever in the third division for the new cell walls to assume a position radial to the outline of the colony as is described for Eudorina at this stage and as Braun thought must also be true for Gonium. Such a modification

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might be expected if there were any tendency here to the regulations which Driesch assumes in his equipotential harmonic systems, since the placing of the third plane of division radially gives in Eudorina a rounded eight-celled group much more nearly resembling the typical sixteen-celled colony of Gonium. The oblong eight-celled colonies have no resemblance in form to the normal colonies and yet they occur abundantly. Their cells grow to normal size and reproduce normally, giving either eight or sixteen-celled colonies, according as the conditions are more or less favorable. I shall discuss this point further a little later. The eight cells as they enlarge are subjected to still further pressure. In rounding up, too, they increase the diameter of the whole colony in one direction more than in the other. The result is that the group becomes curved, as is shown plainly in edge views (text figures 3 and 4). The fourth division occurs at right angles to the third and we get thus the two rows of four cells each divided into two rows and the sixteen-celled colony is thus produced with four cells forming a square or rhomboid in the center and twelve cells forming a peripheral series about them. Such colonies are shown in figures 1 to 9 in successive stages of development.

That the spindle figures always lie in the same planes in the successive divisions may be due to intracellular organization or perhaps, and more probably, in the third and fourth divisions to external stimuli. As noted the cells round up considerably after each division and are thus subjected to pressure from the swollen mother cell wall. This pressure on the edges of the four celled plate may be a stimulus which aids in determining the plane of the next division. At the eight and sixteen celled stage the curved form of the young colonies is good evidence of pressure from the mother cell wall though the latter has become so gelatinized that it is very difficult to make it visible under the microscope. The young sixteen-celled colonies are quite saucer-shaped, as has been observed by the earlier students of the colonies. Kny[10 and 11] has demonstrated the effect of pressures and tensions on the plane of cell division. He concludes that there is a tendency for the cells to divide at right angle to the plain in which pressure is exerted upon them though this tendency may be overcome by his so-called "internal forces." It is certainly impossible as yet to ascribe to pressures and tensions any

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universally constant effect on cell growth and division, though there can be no question that both may act as determining stimuli in specific cases. With such stimuli present it seems at least unnecessary in the case of Gonium to assume any specific preformation of the germ plasm to determine the plane of cell division in the young colony. The major growth of the colony here is against the pressure of the mother cell wall just as in Hydrodictyon, as I have pointed out, the major growth of the cells is against the pressure of the adjoining cells in the young net.

That the curvature of the young colonies is purely mechanical and is forced upon them by their environment is plain from the fact that a little later when the mother cell wall breaks the plate flattens out immediately. In some cases the mother cell wall may become so distended that this flattening out takes place while the young colony is still enclosed.

In the development of the colonies as just described we have apparently an example of mosaic development. The original parent cell could be laid off into a series of sections, by lines cutting each other at right angles, so that each fragment would represent a cell of the future colony in something near its proper relations to all the others (text figure 7). There might be conceived to be a localized area in the germ cell representing each particular cell of the adult organism. The germ cell has merely been expanded and cut up into pieces, each of which becomes a definitely placed cell of the completed colony.

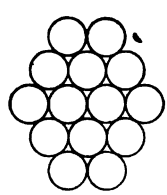

Fig. 6

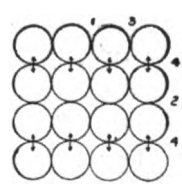

Fig. 7

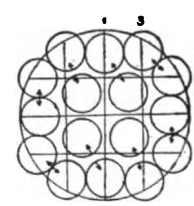

Fig. 8

In text figure 5 I have drawn the outer boundaries of the gelatinous cell walls. These outer layers are apparently denser and more resistant and with the swelling of the inner layers become stretched into figures representing very diagrammatically the arrangement of the cells of the parent colony. The expansion and rounding up of the cell walls leads to their separation everywhere except

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at the points of protoplasmic continuity between the adjacent cells. Here, although the plasmodesmen have evidently been withdrawn, the pit structure of the cell walls persists as a region of stronger union between the adjacent cells. It is interesting to know that this pit region, or at least the so-called middle lamella which forms the floor of the respective pits, is of about the same size between each pair of cells and appears as a definite disc-like region of connection, from which the cell walls are stretched to form the triangular intercellular spaces which are now very much larger than they were before the swelling of the cell walls occurred. As noted above, this particular colony was one of those whose central group of four formed a rhomboidal rather than a square figure and the point of union of the two cells that are in contact and the wide separation of the other two is conspicuously shown at this stage. It is obvious that a colony of this form is characterized by the greatest possible compactness in the arrangement of its cells. The intercellular spaces are triangular throughout, showing that the globular cell bodies have come into as close relations to each other as possible. Such an arrangement as this, as noted above, would result from surface tension and adhesion between viscous colloidal globules.

The cilia are shown still present with a number of the cells of the colony as they appeared at this stage and in two cases still showing feeble movements. It would seem probable that the connection of these cilia through the cell wall with one of the daughter cells of the new forming colony is maintained, though this is difficult of determination, and it is not impossible that the movements are autonomous and that the cilia have been broken off from connection with the parent cell at this stage. The persistence of the cilia at these late stages in cell division has been observed in other members of the volvox series. The daughter colonies proceed to grow now to the size of the parent and in this process of growth adhesion and surface tension play a part in developing the details of the mature structure as was suggested above. The daughter colonies escape from the mother cell walls during the night and in the morning I find them swimming freely, with no evidence as to their origin. In the case of my material if the plant were studied merely in the day time an increase in the number of colonies would be observed, but with no suggestion as to how they arose.

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Since all the cells tend to be of equal diameter and circular in section the production of the mature colony with the definite space relations between its cells requires very considerable readjustments. If division and growth took place without gliding of the cells upon each other we might get a square colony such as is shown in text figure 7. The arrows indicate the pairings resulting from the last division. A comparison of such a diagram as this with any of the photographs of the normal colonies shows at a glance that the readjustments occurring in the formation and growth of the colony tend to a more stable arrangement of the cells and greater compactness. The square intercellular spaces are all replaced by triangular intercellular spaces except in the one case between the cells of the central group of four. The main modifications arise from the crowding in the outer series of twelve since ten is the normal number to form a series about a group of four (text figure 6). If the colony consisted of fourteen cells the crowding and consequent tensions would disappear. In the young colonies, as a matter of fact, the twelve cells of the peripheral row are much compressed laterally in order to maintain connection with the central group of four (Figs. 1-6). In the very young colonies the cells are much flattened upon each other. This may be due to loss of turgor due to a reduction in the amount of osmotically active substances during cell division or it may be due to stronger adhesion between the young cell boundaries. As growth proceeds, the cells tend to round up more and more and this brings to bear a stretching tension on each of the four of the central series, which tends, as noted, to flatten them out, that is, increase their diameter as seen from the face of the colony, at the expense of their vertical diameter. It also tends to draw them apart from each other, and in the vast majority of cases, results in the production of the square intercellular space in the center of the whole colony. In the adult colony, for this reason, the central cells seem larger, but there is no evidence that they really are greater in mass, their apparently increased size being due to the flattening just described. The tensions which are brought to bear on the central cells may be best understood perhaps from such a diagram as is given in text figure 8, in which the large circle and the lines from 1 to 4 represent the mother cell and the successive planes of its division. The small circles represent the daughter cells in the relative positions which

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they occupy in the adult colony. The inner group of four have maintained approximately their original position while the outer series have been shifted about them. The arrows indicate the pairing of the daughter cells of the last division. This shifting of the outer series around the inner group leads to the greatest compactness with the least possible readjustment of the relations of the individual cells. If the inner cells were shifted with reference to the outer series two of the pairs of sister cells would be widely separated in order to produce the configuration of the adult colony. It is plain that in such a system, the cells all tending to round up, very considerable tensions may be developed and that as noted the central cells will be flattened and the peripheral cells compressed laterally as they are seen to be in the photographs of the young and growing colonies.

The method of reproduction of the cells by simple bipartition with rectangular intersection of the successive planes of division and the surface tensions of the viscous colloidal protoplasmic masses of the cells with their internally determined pear-shaped form and capacity for forming protoplasmic connections give two sets of factors whose interactions determine the shape of the cells and of the intercellular spaces and the shape of the whole colony. The relative diameters of the cells give a suggestion at once of the relations of pressure and surface tension between them. The outlines in the micro-photographs are not perfectly sharp and since the peripheral cells lean outward more or less the photographs show them in more or less oblique optical section while the central cells appear in transverse section. None the less the fairly constant and interesting evidence of lateral compression in the peripheral cells and flattening in the central cells is unquestionably an expression of factors of surface tension and adhesion present in such a system. The tangential or periclinal axes of the central cells are about equal to the radial axes of the peripheral cells. The radial axes of the inner cells are intermediate between the two. The four cells of the outer series which are withdrawn somewhat toward the center of the colony tend to be pear shaped in optical section and seem perhaps to be less compressed laterally at their bases than the other eight of the series.

It is evident that to provide for the pit connections which are seen to be present in the old colonies secondary unions must be estab-

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lished wherever cells are in contact. Sixteen such connections must be established in the ordinary colonies and 17 in the rhomboidal colonies in addition to the eight that may be regarded as persisting between the sister cells in the last division.

That as noted the colonies are under considerable tension between their parts is experimentally demonstrated at every stage in their study. To obtain the photographs it is necessary to kill the organisms in order to bring them to rest. This is a matter of some difficulty since it was immediately found that any shock from poison or by other means which would lead to a contraction of the protoplasmic mass would result at once in breaking up the colony. Extreme dilutions of Flemming's weaker solution were used. Slight changes in the turgidity of the cell, due to a change in the concentration of the medium have the same effect. Any sudden shock leading to further rounding up or contraction is practically certain to break the adhesion and protoplasmic continuity between adjacent cells and the colonies fly apart with a succession of sudden jerks, as can be easily observed under the microscope. Figure 22 shows a colony so broken up.

It is not uncommon to find that in the ordinary course of their existence the continuity between certain cells in the colony may be broken, and thus square or oblong instead of triangular intercellular spaces are produced (Fig. 7). As noted the mature condition shows the cells well rounded (Fig. 8). The walls have become gelatinous and swollen and the plasmodesmen tend to be withdrawn though the pit connections may become more prominent. The colonies sometimes split through the middle, thus producing two eight-celled colonies (Fig. 16). These are, however, different in form from those which result from the interruption of the normal process of reproduction. The eight-celled colonies produced by the interruption of the division of the mother cell vary considerably in their form. The most common type is that shown in figures 17 and 18. Figure 20 shows a very aberrant type seen only once.

These eight-celled colonies indicate most clearly that there is no tendency in Gonium to the process of regeneration. They remain in the form in which they are produced, whether as a result of splitting the parent colony or from dwarfed development in reproduction. The cells of the eight-celled colonies formed by dwarfing undergo

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rearrangements due to surface tension during their growth analogous to those which take place in the sixteen-celled colonies and as a result they regularly consist of two compact rhomboidal groups of four cells. These two groups may, however, be quite variously placed with reference to each other, as is shown in the figures just referred to. There is no tendency to morphallaxis or regeneration of any sort. The individual cells of Gonium are totipotent and capable of reproducing the whole colony in its perfect form by normal reproduction, but if the process is interrupted the product is not a diminutive model of the adult type, but quite a differently organized individual, as is also true of the half colonies produced by fragmentation. There is no reason in the nature of the case why if the arrangement of the eight cells were controlled by some regulative teleological principle it should not operate to rearrange the eight-celled groups into a form corresponding to that of the normal sixteen-celled colony, only on a smaller scale. This could be accomplished by putting two cells in the center with eight around the periphery, or one in the center with seven around it, or we might have the crossed arrangement found in the eight-celled stages of Eudorina.

The four-celled form of Gonium is generally regarded as a distinct species. The material of this type which I have had for study appeared in a pool in which the sixteen-celled colonies had been very abundant but were beginning to disappear. Eight-celled colonies were also relatively more numerous than they had been before and the conditions suggested strongly that the four-celled colonies might be also degenerate forms of the sixteen-celled type. I was, however, never able to observe the formation of four-celled colonies from the sixteen-celled type. The adhesion between the cells in the four-celled colonies seems very weak and the cells early round up so as to form the characteristic square intercellular space between them (Figs. 21, 22).

We have in Gonium an organism of definite and characteristic structure whose heredity and ontogeny may be expressed in terms of cell organization and simple mechanical interactions of the cells in their growth from the germ cell to the mature condition. The most fundamental feature in the cell organization is that which determines

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that the successive planes of division shall intersect at right angles, the spindles lying always in the same plane. I have not been able to work out the processes of nuclear and cell division in these minute cells. On the basis of the work of Timberlake and others on nuclear division in the water net and other algal cells we may assume that a centrosome is present here and that the spindle is formed in connection with the divergence of two daughter centrosomes. The intersection of the successive planes of division at right angles implies that, as is generally the case, this divergence extends to a distance of 90 degrees for each of the daughter centrosomes and that the plane in which the divergence occurs is maintained unchanged. either as a result of internal cellular organization or external stimuli. In neither case would any specific representation of the form of the colony in the organization of the germ plasm be implied.

The method of forming the colonies in Gonium stands in marked contrast with that in the water net. We lack here the convincing evidence that the structure of the germ plasm does not represent the space relations of the parts of the adult, which we have in coenobes which are formed by the aggregation of free swimming units, still it seems to me gratuitous to assume in the cells of Gonium any complex specific representation of the structure of the colony as a whole. It is obvious here that the organization of the whole cell which may determine the position of the spindle and the planes of cell division is in no specific sense an *anlage* for the form of the colony and the colloidal qualities of the protoplasm which determine the adhesive and surface tension qualities of the cells are factors in quite another category than the space relations between the cells which they determine. Gonium illustrates clearly the numerous and complex interactions of the most delicate and intensive sort which may arise between cells as a result of their properties as colloidal droplets on the one hand and their fixed method of reproduction by bipartition on the other. These interactions may have much to do in determining the method of formation of such globular colonies as are found in other members of the volvox series.

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THE MODERN THEORY OF THE CELL AS A COMPLEX OF ORGANIZED UNITS

By E. W. Roberts.

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I. INTRODUCTION AND DEFINITION

The matter herein is not presented in a dogmatic, but rather in a suggestive, spirit. It is believed that the photographs present evidence in support of the views advanced.

*The writer wishes to extend his thanks to all who have aided in the preparation of this work. In an especial way he wishes to express his obligation to Dr. S. G. Shanks of Albany, N. Y., and Mr. Frank Dienelt, Loda, Ill., both deceased. Dr. Shanks was much interested in the theories advanced in the paper and prepared some 800 slides of serial sections from which these cytological photographs were made. Mr. Dienelt introduced the writer to beauties of insect microscopy. This great hearted farmer, microscopist, and astronomer was, for more than 60 years, an arduous worker in the advancement of his favorite studies. During this time he made upward of 20,000 microscopic slides illustrating insect structure.

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The writer has found the view that the cell is composed of smaller units, each of which has a somewhat sharply defined work, of great value in forming a comprehensive mental picture of living matter. While this view, as opposed to that which regards protoplasm as a definite substance, is in no sense new and is the one held by most cytologists, the writer believes that the real significance of this newer view has not been fully realized by students.

Life is not to be looked upon as a force or a principle, but rather as the sum total of the component materials and forces entering into a given relation. The recognizable persistence of such a relation, we speak of as its life. Any change in the components entering into a given relation produces a corresponding change in the net result. This accounts for the constant change in the expression of all organic and inorganic groups, which is called evolution.

Text-books have taught for the last fifty years that the cell is *"the unit"* of such "living," organic structure; and that it is composed of a mystic jelly substance called protoplasm, which jelly (by powers equally mystic) is capable of carrying on all the varied processes of life.

Many modern workers are inclined to believe that the cell is not *"the unit"* of organic structure, but that more correctly speaking it is only one of a series of natural groupings, being in fact a whole household by itself, made up of smaller and smaller groupings of units governed entirely by natural chemical and physical conditions.

In the spirit of this conception the cell, which is in truth a convenient unit, may be described as a series of groupings of structures, increasing in complexity upward, arranged by past environment, and capable of modification by present environment.

Certain of these smaller units that make up the cell are clearly recognizable with the technic of the day; some of them at the other extreme are of the order of the molecule, with which the chemist must acquaint us; doubtless there are still other intermediate units lying between these extremes about which, at the present moment, we can only speculate, since they are too minute for microtechnic and too complex and multiform for satisfactory chemical analysis.

For more satisfactory approach to the problems involved I propose the following analysis of the cell structure; and taking the cell

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as the "unit" of study we may conceive the following order of subordinate units:

1. Intra-cellular units of the *first* order:—the nucleus; the cytoplasmic mass; and possibly the centrosphere. These seem to be somewhat coordinate in rank and subject to recognizable interactions.

2. Intra-cellular units of the *second* order:—(a) Within nucleus—chromosomes, spindle fibrils, etc.; (b) without nucleus (cytoplasm)—chloroplastids and other plastids, pyrenoids, centrospheres, etc. As a collective, descriptive term for the various kinds of units of this order, within the nucleus, I propose the term *nucleosome;* for those constituting the cytoplasm, the term *cytosome.* In the light of our ignorance of just what portions of the protoplasm do the particular things done within it, it is desirable to have such a term referring to the complex and composite nature of protoplasm in order to prevent us looking upon these *various products as formed by the whole body of matter as a unitary mass.* It is the thesis of this paper that *work of the cell is done by the differentiated units of which the cell is composed, rather than by a "substance."*

3. Intra-cellular units of the third order. Our analysis of this order of unit halts and awaits a more perfect technic. We have, however, gone far enough to feel that the chromosomes of the nucleus are composed of bodies—granules—arranged with some definiteness upon the linin thread-work. Whether there is a similar differentiation in other cell units we cannot say certainly from observation.

4. Intra-cellular units of the nth. order. Here belong the chemical unities of the order of the molecule. It is not the purpose of this paper to discuss the units of this class. We can only say that the characteristics of the higher units come from the character and relations of these; and that there are probably several series of ascending units between these and those suggested under 3 above.

Some of these subordinate units at least are endowed with one particular distinguishing quality: they undergo binary division at certain periods of their growth. It seems probable indeed that this is the process by which *all* organic groups multiply; and it is possible

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that this extends even throughout the ultimates of inorganic phenomena.

2. GENERAL DISCUSSION OF CELL STRUCTURE

The cell, as a rule, consists of a body composed of smaller units, which carry on all the vegetative processes of the group. This is usually termed the cyto-reticulum. This cyto-reticulum body contains an important structure called the nucleus, which plays an important part in the divisions of the cell, both direct and indirect. The nucleus, as we find it functioning in indirect divisions of the cells in higher forms of organic life, was not always present in the complexity in which it now exists. This is suggested by the fact that it is structurally much simpler in the lower types of cells.

It must have developed from its phylogenetic ancestors, just as is true of all higher organic structures. Its functioning as a compound division-organ may have arisen from the compounding of the binary division functions of lower organic units whose union gave rise to it.

The cell as we know it today, represents a line of descent from a remote geologic past, its present structure of nucleus and cytoplasm having grown from primitive groupings of lower and lower elements.

Furthermore the organic is but the inorganic in certain natural groupings. Life both comes into view and disintegrates from its groupings by natural processes. The more we know both of organic and inorganic, the more reasonable becomes the assumption that the principle of the inorganic is the same as of the organic.

Strasburger states the matter in this way: "The original protoplasm had no nucleus, all its parts being capable of both formative and nutritive functions. Then there was a gradual separation of both formative and nutritive parts, and the formative parts were the first differentiated carriers of hereditary qualities.

At first they were scattered in the cytoplasm, but later they became grouped, as in the Cyanophyceae; next the nucleus would be marked off by a membrane. Simple constriction might suffice for the division of such a nucleus, but as the difference between the hereditary units became so great that each unit carried only one quality, a more exact division would become necessary. The units

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would become arranged longitudinally in a thread, where they would undergo doubling, and the longitudinal division of the thread would separate the products of that doubling."

3. ILLUSTRATIONS OF SUCH UNITIES OF DECREASING VALUE

All organic structures show arrangement comparable to this; these relations are determined by natural conditions and are seemingly but a recapitulation in all the groups.

A typical series might be thus enumerated: nation, state, county, city, person, cells, cytosomes, daughter cytosomes, etc., clear down to the negative electrical corpuscle which is now deemed by many to be close to the border-land between matter and energy.

In a similar way, a series of animal structures such as muscle serves well as an illustration. The muscles cover the skeleton, and give form to the body; the muscle group is made up of individual muscles, which in turn are made up of bundles of muscle cells; these muscle cells are constructed of intracellular fibrils, which in turn are formed of smaller units.

Such groupings might be further illustrated, but enough is shown, to illustrate the *fact,* that higher groups are all composed of smaller groups, extending indefinitely lower apparently than optical instruments alone will ever carry us.

4. COMPARATIVE STUDY OF CELLS

There is a crying need for comprehensive knowledge of the life history of the various types of cells. In order to be effective this must be comparative and be based on the three great phases of cell life, the complete ontogenetic stages through which a cell passes on its way to its natural end:—viz., its

Pro,—or growth,—stages.
Meta,—or functioning,—stages.
Ana,—or disintegration,—stages.

The probable phylogenetic significance of the ontogenetic stages of derivation and development would form an interesting phase of the treatment,—numbers of types being brought together for comparison.

A knowledge of the chemistry and physics of the various types at different stages is badly needed, also of the relations of cell types

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to their neighboring cell types, and to their other environmental conditions; and as badly needed as any phase, is an understanding of the relation between the vegetative cytosome system and the nucleus.

This is a gold mine of the future; no better field lies before the young student of biology.

Muscle Fibrils, as Differentiated Within the Cell

That the cell can be extremely complicated, is well shown in figure 3, of the long section of the multinucleated muscle cells of a spider's leg; it will be plainly seen that the cell cavity contains many nuclei, scores of them in some cases. These giant muscle cells may be degenerate muscle bundles in which the walls of the component cells are not developed. In such a case the structure is termed a syncytium.

The walls of these cells, of which a better view is had in a cross section (Fig. 4), are seen to be lined with long bundles of cytosomes, which arise in plastids derived from the nuclear reticulum.

The plastids from which such cellular fibrils originate are well shown in figure 1, and a later stage of the same in figure 2, from the back thoracic muscles of the Tussock Moth. The female of the Tussock Moth is wingless, and as a result we may expect to find early atrophy of the back thoracic muscles which move the wings in this sex.

Figures 1 and 2 both represent the female of this moth at two-day intervals. In figure 2 all but two of the muscle cells show distinct signs of degeneration, being much shrunken.

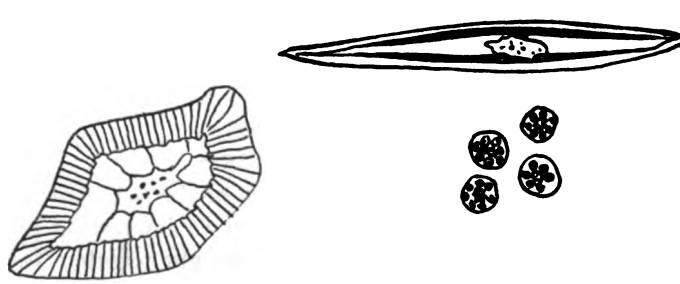

Fig. A.—The muscle cells in the leg of Spiders. The large cross section shows the fibrils arranged in flat radial plates: from the leg of *Anglena*.

The longitudinal sections and the small cross sections are in the early blast-stages, from embryo of *Lycosa*.

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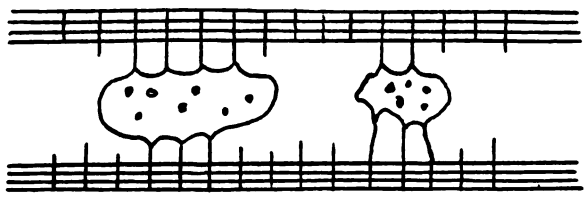

Fig. B.—Diagram of the nuclear attachments with the cytosome fibril system, in the leg muscles of a Spider, *Agalena.* Nuclear extensions are connected with the cell membranes.

Figure 5 shows the muscle-cells of a newly hatched frog tadpole's tail; the cytosome fibrils are in active stages of binary division. Many of the cells are multinucleated, and all these early stages of cells contain cytosome plastids of elaborated foods, commonly called the yolk grains; these are used as food for the growing fibrils.

Figure 6 is a long section of the back thoracic muscles of a fly pupa. Note the cyto-yolk grains and tracheal tubes between the muscle bundles; also the perimysium cells in the fibril bundles.

Figures 7 and 8 show long and cross sections of the developing cytosome fibrils in a Salamander pup. Note the increasing bulk by binary divisions of the fibrils.

It has been taught for years that the contractile and extensile powers of cells are due to what was termed "the general contractility of protoplasm"; this is evidently an error, as close observation will show that the motile and contractile powers are due to specific cytosome structures, in many cases in the form of fibrils.

The tails of sperms, all muscles, cilia, flagella, dendrites, pseudopodia, nerve fibrils, etc., are moved by contractile cytosomes.

In figures 9-10 the vegetative stages of sperm development are shown. They are from the testicle of a salamander. The entire shape of the cell and of its appendages is here determined; the motile tail has cytosomes which both form and move it.

All the Protozoa or single cell animals and plants are extremely complicated, and have the cytosome structures elaborately diversified in function, as contractile and sensory fibrils, secretive and excretive organs, and in some cases sexual organs; they are not the simple jelly masses often described in text books.

Figure 11 is a section of the intestinal cells of the Carpenter

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Ant. The photo shows nicely the cytosome fibrils which form and move the cilia on them.

Figure 12 shows the developing sperms in the mother-cells of the earth worm. The sperms are developing the cytosome fibrils in the tails in a variety of stages.

Theory of Ebb and Flow of Units From Reticulum to Nucleus

The cyto-reticulum cell-structures are extremely complex in nature, and they show modifications for the performance of a great variety of function in a single cell; the division of labor among them is in some cases as varied as a more highly organized metazoan group, each individual cell having need for more or less of all the physical requirements of the higher groups.

Paramecium is a good subject in which to study the diversity of cytosome structures in a single cell. It is to the variations in the arrangements and functions of these cytosomes, and their smaller component groups, that we owe the great variety of expression found in organic life.

They are the true vegetative body of the cell, and it is possible that their arrangement and character is transmitted to the nucleus by minute representatives of the vegetative groups.

These representatives are assembled on the nuclear reticulum during early pro-stages of indirect or mitotic division; during direct division of the cell these representatives are not used, as the entire vegetative body is directly divided.

As in a metazoan group we find the body characters are transmitted by the sex sells, it follows that these characters must have been received from some source before they could be reproduced or given out again. Thus we see a constant working of a process in both directions:—the nucleus constantly buds out the characters of the cell body, while the body characters as constantly modify the nuclear characters.

This principle may be illustrated from a yet higher grouping. A nation, state, city, etc., will be constantly modified by emigrants from other countries, states and cities, the modification depending on the relative proportions and strengths of the new factors, the whole assemblage being also as constantly modified by the total environment.

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In a similar way it may be argued that the cytosome body bears a corresponding relation to the nucleus; and we believe this point should be most thoroughly investigated, as no history of cell life can be complete without it.

Mutual Stimulation of Cells in Tissues, and Its Results

As, in the ontogenetic development of a metazoan group, new types and functions and groupings of cells constantly come into view, we suggest that such new types should arise in many cases, by some form of cell association,—a semi-conjugational arrangement.

Phylogenetically we well know that many new types and varieties arise by conjugation. This is the advantage of sex and indirect division,—that we get greater variety, and as a result greater resource from uniting differing individuals, than from like individuals.

Such a mutually stimulating grouping of a non-conjugating nature is shown in figure 13, of the giant spines or sexual horns on a male fly; figure 14 is a photo of the giant nuclei of these horns, while figures 15 and 16 are vertical sections of giant spines from other parts of the fly's body.

We have examined the nuclei of hundreds of the giant spine cells on this pupa, and all alike show in section, various numbers of cells with their nuclei in contact.

The explanation that seems reasonable, is that many of these spines arose in their phylogenetic development as a result of mutations produced by mixing slightly varying individual cells of the same or allied varieties.

In figures 18 and 20 will be seen the so-called "nurse-cells" which aid in forming the ovum. These nurse-cells are evidently of the nature of the stimulating cells in these giant spine groups. Their function must be something more than supplying food, for they themselves have to be fed so they may attain their giant size. They are constant in number in a species; thus this variety of Ephemera has six, while the variety of Mosquito has four and a variety of Chironomous has only one.

The real food cells are evidently the jacket of small cells which surround the ovum. From these small cells come the chromidia which form the yolk cytosomes.

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There are also, in the embryo sac of all higher plants, various numbers of large cells cut out along with the ovum cell. This phenomenon is quite widespread, and it seems as if blast cells requiring large amounts of nutriment cannot encompass the task without other cells of large size in the group.

This is an interesting field for research.

There are various other conjugant cells in different tissues of these young animals that show similar arrangements; but this being a striking type, we offer it in hope of stimulating further investigation.

Qualitative Differentiation of Cells, Leading to Mutants and Tissues

The two cells resulting from mitotic division are not in all cases like their progenitor; they are in many cases progressive mutants. That is, the contents of the cells resulting from the divisions may differ much in their vegetative functions and in their subsequent development. This becomes very evident when we watch the development of their vegetative systems from the nuclosome divisions of the nucleolus. The nucleosomes show variations in number, shape, size, position, structure and functions.

There thus arises in metazoan tissues a constantly varying type of cells, which is supplemented in many cases, such as ferns and other lower plants, by well known semi-conjugational cell arrangements. This is usually known as apogamy.

These mutations have an ancestral origin.

Effects of Varying Food Upon Cells and Cell Parts

We also suggest that the new types of cytosomes which elaborate the yolk granules and other food products in these growing cells, may have a direct modifying action on the other cytosomes which use them for food.

Food and the quest for the same, has been a great factor in the development of organic life, and it is wise to investigate the ontogenetic development, to detect traces of such reaction.

Yolk Formation in Eggs and Embryonic Tissues

If the type of product to be elaborated in a cyto-plastid is of a

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food nature, the daughter cytosomes do not remain adherent as in fibril products, but lie freely in the plastid wall in a semifluid mass.

The yolk of all egg cells is formed primarily by these cyto-plastid inbuddings; this is a very elaborate process, and spreads over the time of the growth of the egg, from the mitosis which cuts out the future sex cell, to the time of the maturity of the yolk products.

A fine type of the elaboration of yolk plastids is shown in figure 17, of the ova of a spider. Here the enormous growth of the yolk cyto-plastids is well depicted.

The sex nucleus of the egg takes little part in the yolk formation of insect eggs; there are special nutritive cells set apart, which furnish elaborated cytosome products. Some of these cytosome products continue their growth in the plasma of the sex cell, there forming anew from the pabulum the typical yolk-cells or plastids.

The nutritive cells form a typical ovilemma around the sex cell. A good type of this is shown in figure 18, of the young ova of an Ephemera, in which case six cells are situated around the micropyle, while a complete jacket of smaller cells form the egg membrane proper.

The yolk cyto-plastids present a close resemblance to true cell types; in some cases showing a cell wall, plasma, and a staining body resembling a nucleus. This body is capable of division and subdivision; see figure 19, of the same Ephemera ova further matured.

Another illustration of these yolk cyto-plastids is seen in figure 20, of the nearly mature eggs of the mosquito.

The yolk of ova is thus seen to be a special product of certain food cells (the ovalemma), which live for the sole purpose of furnishing food for the future embryo.

In developing embryos there is constantly a part of the cells set aside to manufacture special foods for the growing tissue cells. This gives the growing embryo a constantly developing and changing diet, and this process will doubtless be found to have a phylogenetic derivation and significance. It gives a continually new and developing food environment, and must be a profound factor in the modification and growth of the ontogenetic series of types of cells and their groups.

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Degeneration of Larval Tissue Into Foods

After the larva is hatched from the egg, the yolk food supply will be found nearly exhausted, and an immediate new food supply must be had. This when obtained is constantly assimilated by the larval tissues, which re-elaborate therefrom according to their needs.

During this larval stage, there is an extensive storage of cytosome food products: fat, yolk ,etc., beside all the larval tissue which will become useless when the pupa stage is entered upon.

These larval tissues as fast as they become ontogenetically useless, suffer anatosis stages and thereby disintegrate into foods. There are countless variations of these processes. In many cases it is accomplished by phagocytosis, as in figure 21, from a moth pupa, and figure 22, from an ant pupa.

There are in many cases anatosis phases on a large scale, and in some cases reversion to primitive organic types will be found.

In a developing pupa such as the Carpenter Ant,—Camponotus, —we have a striking illustration of the great variety of types among the food cells. These types are all grown in certain hereditary locations, and have in each type certain elaborated food products, which mature at certain times, and have certain stages of growing cells to feed. When mature they either undergo anatosis where grown, or migrate by amoeboid movements, or in blood streams, to where they are to be usd.

In one type of food cell there are two large bilateral plastids developed, which dominate all the other plastids. The other plastids develop as a swarm of dark staining bodies on the reticulum of the nucleus, between the dominant plastids. (See Fig. 23.) In another type the plastids are developed in many equal sized bodies as shown in figure 24. In still another type of these food cells, they become detached and are carried in blood streams into the developing legs, etc., where they undergo anatosis reduction into blood pabulum and are used as food.

Some Special Cell Structures, Pigment Masses, Pseudopodia, Etc.

It should be kept in mind that cells with irregular outlines are hereditarily just as marked, and have just as natural groupings in their fundamental makeup, as the most symmetrical ones. A glance,

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for example, at the irregular outlines of the pigment cells of a salamander (Fig. 27), will show the apparent anastomosing of the pseudopodia; these reticulated appearances are caused by the branching of the groups of cytosomes, the branches becoming superimposed in the focal plane.

Figure 28 gives, for comparison, a view of a pigment cell from a young fish embryo, with the fibrils in a conventional radiating arrangement.

In a pigment cell the cyto-fibrils are self delineating; in an object as colorless as an Ameba in a living state, such structures are practically invisible, only proper fixing and staining reagents being able to show them. In fact, this is the reason so many writers have called them "structureless protoplasm."

In Polycistinæ, Foraminifera, Rhizopods, etc., the pseudopodia are sent out at certain hereditarily determined places in the cell wall, forming "arm holes" in the silica, lime and chitine cases. (See Fig. 29 and Fig. 30.) These arms are merely cytosome structures, which are capable of extension and contraction. Some writers figure the so-called spindles of these pseudopodia, but none seem to realize their value.

During life a continual flow of cell plasma with floating corpuscles of cytosome derivation, may be seen over and among the fibrils. This flowing, streaming and boiling of cytosome products is due apparently to chemical and physical changes which take place on the addition of various components, by which the chemical balances of the groups are all thrown out of place and new readjustments follow. This furnishes us with the processes which are spoken of collectively as life.

Epidermal Cells and Their Products

The markings on insect hairs and scales are all cytosome products, and they serve a variety of purposes, from mimicry to the gorgeous color effects seen in flies, bees, beetles, butterflies, etc. (See Fig. 31, of the scales of Lepisma; and Fig. 32, of the cyto-fibrils in the walls of moth scales in cross section.)

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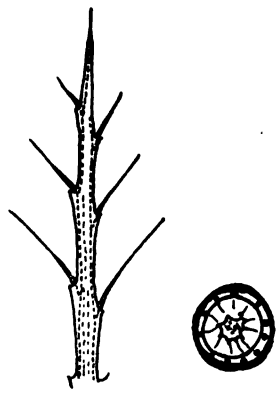

Fig. C.—Diagram of cross and longitudinal section of scale of Tussock moth, showing arrangement of fibrils.

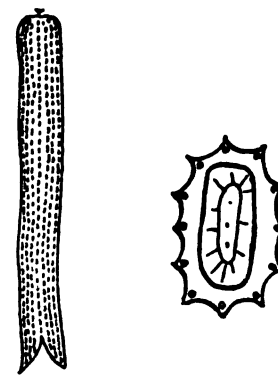

Fig. D.—Diagram of Branching spines of a spider, showing long and cross sections of the system of fibrils.

These scales are formed by vesicular sac-like extrusions of certain epidermal cells, and are caused by the growth and arrangement of the cytosome structures, which form groups of fibrils by binary divisions of the cytosomes remaining adherent in a longitudinal manner. These cyto-fibrils, by their aggregate extension, push the wall of the cell outward, forming a vesicle, in which the fibrils are plainly seen as the striations; later the vesicles are flattened or otherwise shaped, and the chitin of the cell wall becomes hardened.

In inscts which go through a pupal stage, very peculiar phenomena occur. When the larva is mature, and ready to enter the pupal state, the larval skin is ruptured and cast off. The insect now has the wings, legs, antennae, etc., well developed. They are folded by the insect ventrally, and the casting off of the larval skin ruptures the epiderm cells, which exude their cytosome products in a fluid state. This forms a coating of slime which rapidly oxidizes in the air, forming the pupal case.

The pupa now being protected by the pupa case, again elaborates its cytosome products in the epidermal cells, but this time they exude slowly, and form the scales as above. (See text Figs. C-G; and Pl. 6. Figs. 31-36.)

In figure 37, we have a strongly stained view of the cytosomes

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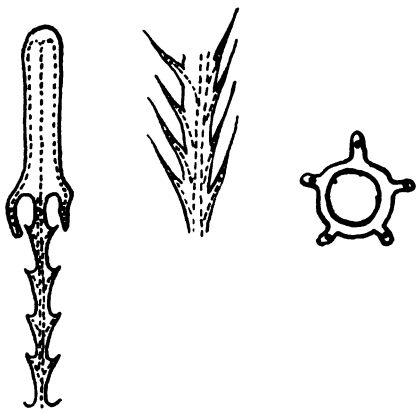

Fig. E.—Diagram of long and cross section of the cytosome fibrils in the spines of Trogdotyle larva. The spines have 5 heads or fibrils.

Fig. F.—Diagram of a multispined cell from the tongue of a Syrphus fly.

in the epidermal cells of a locust. By the extrusion of these cytosomes we get a variety of products: plain chitine, single scales, branching scales and multispined scales.

All the chitin structures of insects are formed by the oxidization of these various cytosome products. The diverse nature and groupings of these vegetative structures produce a multitude of external markings in organic life.

All the cell processes of assimilation and excretion are carried on by these cytosomes, and all the various animal and vegetable structures are the results of their groupings.

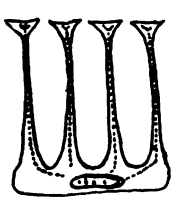

Fig. G.—Multi-spined cell from the pulvilli of a fly's foot; showing cytosome fibrils.

Figure 38 is a section of the spiral tracheal tubes of a butterfly larva, *Mamestra picta*. The tubes are of dermal origin and consist of a layer of hypodermal cells which pour out their cytosome prod-

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ucts into the lumen of the tubes, where the products are oxidized into a chitinous intima. This intima is thrown into spiral crenulations or threads by contraction and relaxations of the muscular system. These tubes sometimes contain dermal scales or spines.

Secretory Cells

In animals all the gland products are elaborated by these cells, a fine type of which is shown in the liver cells of a spider (Fig. 39). Here will be seen the cyto-plastids full of their peculiar products, while those on the margin are breaking down in ana-phase, and voiding their contents into the duct, where it is conveyed to its place of disposal.

Figure 40 is a view of the salivary glands of a Katydid. The large plastids are full of the peculiar semi-fluid cell-products.

Binucleate Cells

In some insects such as Apis, and some Hemiptera (See Fig. 24), the intestinal and fat cells will in many cases be found binucleated. It is believed that these nuclei are physiologically different. One nucleus, and its cytosomes, is vegetative undergoing anatosis, the elaborated products being discharged into the food mass in the intestine. This nucleus is as continually replaced by division of the other, which is a generative nucleus. This adaptation may be due to the quantities of fat used in wax and other products.

In most animals, however, the secreting cytosomes elaborate their products several times in succession; and finally the entire cell contents are voided, the cell being replaced by a new one.

During anatosis the cell products are disposed of in two ways; (1) voided into ducts and carried from the body (excretion), or (2) emptied into the blood circulation, there acting as a food or stimulus for other cells in a pro- or meta-stages.

Anatosis is sometimes called "self phagocytosis," and is a widespread function in the animal and vegetable world; phagocytosis by amoeboid cells may be considered as another phase of this phenomena.

Anatosis is the complement, or the opposite, of digestion; by the discharge of anatosis products into food masses the food is

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partically disorganized, and is then absorbed by other cells in a meta-stage, which re-elaborate it. They then undergo anatosis themselves, voiding the products into the lymphatic or the blood system (as the case may be), by which it is carried to the other cells of the group, which use the nourishment for pro- and meta-stages.

This constant succession of pro-, meta- and ana-phases of cytosome life keep alive the body of the person or cell group. Certain series of cytosomes constantly undergo ana-phases, that new groups may undergo pro and meta-stages. When the pro and meta-stages no longer equal the ana-stages, deterioration and death ensues.

This occurs naturally when the series of acquired hereditary* characters are completed in the ontogenetic development.

Formation of Walls and Skeletons by Cells

The cytosome membranes of many types of cells, which in many cases form the structural basis of cell walls, are often filled in with deposits of various substances, such as lime, silica, chitine, cellulose, etc. These substances do not easily decay, so we have many fine records left us of the arrangement of the original cytosomes which formed the membrane, in and on which the deposit was laid. Such elaborate deposits are well shown in Diatoms, Polycistinæ, Foramimfera, Sponge spicules, etc.

These cell walls all owe their peculiar form and structures to the minute (cytosome) groupings of the vegetative bodies of the cells.

Nerve Cells

Figure 43 is a section of the optic lobe of the brain of a moth. The multitude of curious extensions which nerve cells put forth are all actuated and formed by the cytosome groups, their various arrangements staining nicely; so intricate is the complex of these cytosome nerve structures that it is now deemed possible that there is not a fixed living cell in a metazoan body that is not reached by their

*Author's Note—It is believed that most students of the theory of Evolution will agree that organisms do acquire new characters, both in an ontogenetic and phylogenetic sense.

The various schools of Evolution merely differ as to the factors and their relative importance in producing the new aspects which organisms acquire.

We have carefully avoided taking sides in these arguments in this work, as they have an abundant literature of their own.

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extensions. It is due to the growth and multiplication of these extensions from the cytosome groups, that we get growth and increase of the cell group. How rapid this growth is will be seen when it is stated that in some insects the complete span of time from egg to mature insect is but a few days.

Figure 44 shows the growth of the cytosome fibrils in the brain cells of a Salamander.

Figures 45 and 46 show the active growing stages of the optical elements of a Tussock Moth eye. There are three days' difference between figures 45 and 46; the number of cells has not increased. The growth is entirely due to the enormous development of the cytosome systems.

Figure 42 shows a cross section of these cytosome fibril elements in the same eye.

5. THEORY OF VEGETATIVE CELL STRUCTURES AND THEIR RELATION TO THE NUCLEUS

The relation of the vegetative cyto-structures to the nucleus is of the utmost importance to a comprehensive understanding of the problem of organic life.

The structure of a typical cell in vegetative stage as conceived by the writer is given in the diagram below (text figure 8).

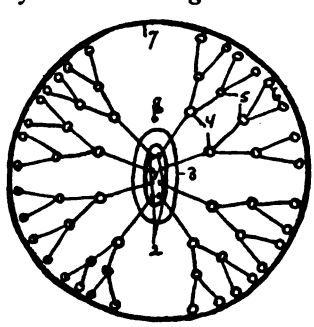

Fig. H.—Diagram designed to show the relation of nucleosomes and cytosomes in the cell. 1, nucleolus; 2, nuclear units—nucleosomes; 3, nuclear membrane; 4, cytosomes or pyrenoids; 5, daughter cytosomes; 6, grand-daughter cytosomes; 7, cell wall; 8, centrosome.

The cell and all its lower cytosome groupings are constantly arranged in halves of duplicate polarity. All these groups have definite family-numbers of components, a minimum point of greatest stability, and a maximum point of instability.

This is in accord with the discovery by Mendeleef of the peri-

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odic law of the elements; it has been possible for him to formulate the principal in accordance with which it is possible to group the various elements in the physico-chemical world into something like a harmonious scale.

The nucleus of a cell contains a body called the nucleolus; this body contains in various semi-fluid forms the balancing polarity groups of units. That is, if the vegetative group contains say fourteen negative pyrenoids, the nucleolus will contain a balancing group of fourteen positive units of equal value. If fourteen is the number at which the components of the group are at their greatest point of stability, an octave higher or double the number, or twenty-eight, will be the point of instability.

The growth of the cell from its point of stability to its adult point of instability is caused by a recapitulation of this same process in all the lower component groups; this continues until by binary divisions of all the cytosome groups, the stability of the larger cell groups is at its weakest point.

The nucleolus units are now attracted strongly by the negative vegetative groups, and this divides the nucleolus units into two groups of fourteen each. These immediately go toward their negative pyrenoid groups, and take their places in the middle of an equal number of vegetative units. Acomplete division of the cell contents is thus effected, both of the resultant cells being at the point of greatest stability.

Illustrated by Rhizopods

We cannot accept the view of Haeckel and other early writers that Rhizopods are the lowest of the forms of single cell life.

The Rhizopods are all parasitic or degenerate animal cells, which live on other organic matter, having lost the power of making their own food through their own chloroplast system.

Therefore we may expect to find the chloroplast system in all animal cells in a more or less rudimentary or specialized condition.

In all the Rhizopods the nucleus forms the chloroplast system by outbudding minute portions of nucleus matter called chromidia; these form all the vegetative parts of the cell.

By the fusion of several of these chromidia the new nuclei of a

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progeny of embryos or gametes are formed, the entire body being thus broken down into young.

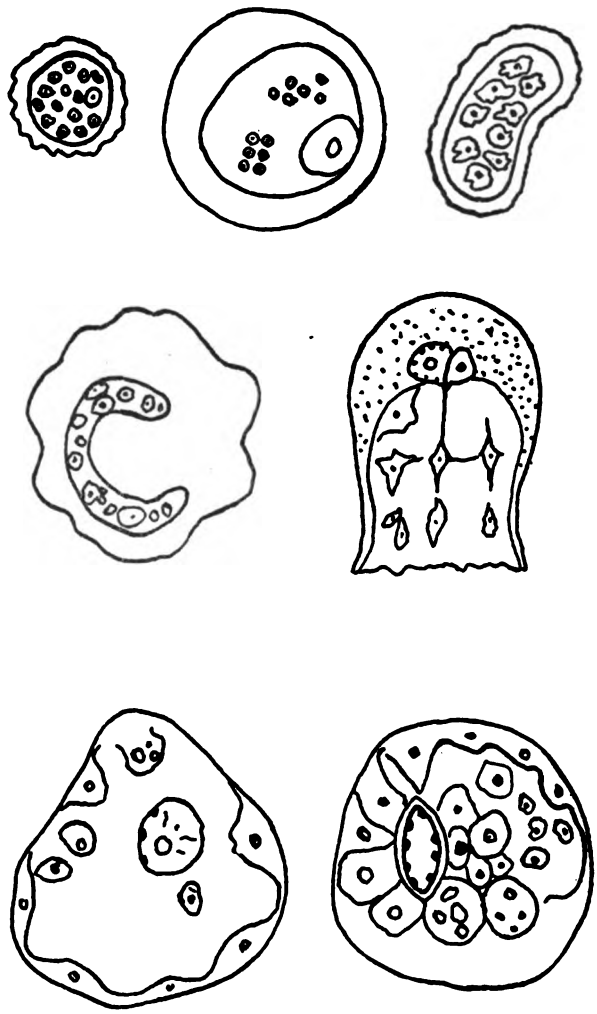

Fig. I.—Reproduction in Rhizopods.

See the works on Rhizopods by Lister, Calkins, Hertwig, Elpetiewsky and Siger.

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Now let us see if this production of plastids in all animal cells is not from similar chromidia fragments budded from the nucleus. In the cyto-plastids from an ant, Camponotus (Fig. 47), we see the swarm of chromidia emerging from the nucleus in all stages of growth. The larger plastids have various numbers of these chromidial granules, which take the nuclear stain very precisely.

Compare this cell with the figure of a Rhizopod by Hertwig (Fig. 44), and the resemblance is striking. There is this difference, however, in the Rhizopod: the plastids become detached as young, while in the food cell of the Camponotus they are specialized as food for growing tissues.

These chromidia are the nuclear elements of all the cytosome systems, and that they are entitled to be called *cells* in some cases is well shown by their ability to reform into definite nuclear structures.

Heidenhain's great work on "The Cell and Plasma" states that these chromidia have been found in all cell structures but muscle fibrils; here it is evidently diffused among other elements.

This agrees essentially with the numerous observations of the author. All the lower protozoa, both plants and animals, form their various swarm spores in this manner from chromidia.

In many cases the nucleus remains intact until after the spores are released, thus showing that the spores are not formed by its fragmentation.

Illustrated by Spirogyra

Spirogyra jugalis has a chromosome number of 14-28.

Several varieties of Spirogyra were examined, and the chromosome number of the type can be compared with the pyrenoid number of the different specimens examined.

Below are tabulated the counts of the pyrenoid numbers in many cells of each kind.

The pyrenoids should be counted only at adult stages or immediately after division; since between these points the pyrenoids are undergoing division and are indeterminate in number:

S. maxima, adult 6 bands, 14 pyrenoids in a band.

S. hassallii, adult 2 bands, 14 pyrenoids in a band.

S. porticalis, adult 1 band, 28 pyrenoids in a band.

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In early vegetative stages of cell life, the nucleolus undergoes a remarkable series of binary divisions, producing within the nucleus a number of daughter bodies known as nucleosomes. These bodies enlarge by vacuolation, forming globular bodies, which migrate in many cases to the nuclear membrane, and in many other cases come to lie entirely outside of the membranes, to which they remain attached by filaments.

A further duplication of this cytosome group now occurs in many cases, the product of the first nucleolus reduction functioning as nuclei for a second generation, which in turn function as nuclei for a third generation, and these in turn produce other generations.

These subdivisions of the vegetative structures all bear a certain hereditary relation to the family type, all being governed by the family pitch or key, under the periodic or rhythmic law. In other words, the family composition is written in a certain key, to which all the factors bear a certain definite family relation, regardless of what the pitch of the keynote may be.

In all these generations of nucleosomes, there are constantly met certain heterogeneous divisions of the various elements, which would at first thought appear to upset the validity of the conclusion. The student of these matters will find plenty of examples for himself.

Mature thought brings us to believe that the keynotes are determined by the averages of the phenomena, not by individual departures from the family type. The averages form the dominant factors, while the variants form the secondary or weaker factors of the assemblage. This idea of averages gives us a good understanding of the results obtained by crossing species with a varying number of chromosomes.

According to Rosenberg, in the *Botanical Gazette* of September, 1909, page 234, he has obtained most interesting results in this line with Drosera plants.

"In D. longifolia there are 40 chromosomes in the nuclei of the sporophyte, and 20 in the gametophyte, while in D. rotundifolia the numbers are 20 and 10 respectively."

"In the hybrid called D. abovata the sporophyte shows regularly 30 chromosomes, the anticipated number."

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Rosenberg "crossed D. abovata with D. longifolia, and while usually there were no results (he) obtained a few embryos. These contained at least 33 chromosomes, and in one case 37 were counted. The theoretical number would be 35."

In the *Botanical Gazette,* Vol. 48, page 179, Gates gives the results of the cross between *Oenothera lata,* 14 chromosomes, and *O. gigas,* with 28 chromosomes; the resultant hybrids show 20 and 22. The theoretical number would be 21.

In figure 47 of the food storage cells of a Camponotus pupa, the nuclei will be seen full of nucleosomes derived from reduction divisions of the nucleolus. These nucleosomes are rapidly growing and becoming drawn outward into the cyto-plasm fluids, in which plasm are found the food products which they reorganize and store in meta-phase.

Later in many cases, after these cyto-plastids have matured their special cytosome products in meta-phase, the contents of the plastids undergo anatosis reduction divisions.

The importance of close observation of the nucleosome bodies during the formation of vegetative bodies cannot be overestimated; probably all had their origin phylogenetically from this source, no matter how obscure their ontogenetic derivation may now be.

During mitosis or indirect cell division, the vegetative opposites forming the nucleolus are supposed to undergo binary division, and take their place as nucleosomes among the minor vegetative representatives on the nuclear reticulum; eventually they form the chromosomes.

The nucleus and nucleolus are reformed in ana-phase of mitosis by a reversal of the pro-stage.

The centrosome is a body which plays an important role in mitotic cell divisions. As the direct or binary divisions of the cell are carried on by the nucleolus, so the indirect division is initated by binary division of the centrosome body. The nucleolus disappears during mitotic cell division, and reappears at telophase; meanwhile the centrosomes are functionally active. Their functions are homologous, each functioning in its own peculiar style of cell division.

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DESCRIPTION OF PLATES

Plate VI

Fig. 1. Cross section of the back thoracic muscles of a Tussock Moth pupa, 4 day stage of a female.

Fig. 2. Cross section of the same group two days later; all but two of the cells are now degenerating.

Fig. 3. Multinucleated muscle-cells from a Spider's leg.

Fig. 4. Cross section of the above muscle-cells from a Spider.

Fig. 5. Long section of the muscle-cells in a newly hatched Frog tadpole tail. The fibrils are undergoing longitudinal binary divisions.

Fig. 6. Long section of the back thoracic muscles of a Fly pupa, Sarchophaga, eight day stage.

Plate VII

Fig. 7. Muscle cells from a Salamander pup, showing the enormous numbers of cytosome fibrils which arise.

Fig. 8. Cross section of the above muscle-cells, showing the rapid increase of fibrils by division of cytosomes.

Fig. 9. Nucleosomes during early stages of sperm formation in Salamander testis.

Fig. 10. Formation of tails by growth of cytosomes in the tails of Salamander sperms.

Fig. 11. The growth of cytosome fibrils into cilia. From the intestinal cells of an Ant pupa.

Fig. 12. The development of cytosome fibrils in the tails of Earthworm sperms.

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Plate VIII

Fig. 13. Giant spines on the head of a male fly.

Fig. 14. Nuclei of giant spines of above, showing the cytosome fibrils coiled in the cytoplasm around the nucleus.

Fig. 15. Vertical section of mutually stimulating cells of giant spines. From a Fly pupa. Sarcophaga.

Fig. 16. Vertical section of mutually stimulating cells of a Fly pupa. The nuclei are in contact.

Fig. 17. The formation of yolk plastids in Spider eggs.

Fig. 18. The nurse cells which secrete food for developing ova. Ephemera.

Plate IX

Fig. 19. Ephemera ova further developed showing the development of the yolk plastids with their cytosome contents.

Fig. 20. Developing ova of the Mosquito, showing the formation of the yolk plastids, also the nurse cells.

Fig. 21. Phagocytes invading fatty tissue. Tussock Moth pupa.

Fig. 22. Phagocytes breaking down tissue in the pupa of an Ant. Camponotus.

Fig. 23. Food cells with large plastids. Camponotus.

Fig. 24. Food cell of a Fly, showing the plastids with their chromidia contents. These chromidia originate within the nucleus.

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Plate X

Fig. 25. Disintegration of food cells into blood pabulum. The cell walls have dissolved and the contents are disintegrating. From the Ant pupa, Campanotus.

Fig. 26. Shows cellular disintegration into blood pabulum in a Tussock Moth pupa.

Fig. 27. Anastomosing pigment fibrils in the skin of the Salamander.

Fig. 28. Pigment cell with non-anastomosing cytosome fibrils. From a young Fish.

Fig. 29. Silicious shells of Polycistinae from Barbadoes Islands.

Fig. 30. Calcareous shells of Foraminifera.

Plate XI

Fig. 31. Scales of Lepisma, showing cytosome fibrils in the walls.

Fig. 32. Cross section of the scales of a Tussock Moth, showing the cytosome fibrils in the walls.

Fig. 33. Multispined cells from the base of a Syrphus Fly tongue.

Fig. 34. Branching scales from a Spider, showing the divisions of the cytosome fibrils which form the branches. Anglena.

Fig. 35. Ornamental spines of Trogdoderma larva. These symetrical forms are all determined by the growth and character of the cytosome fibrils.

Fig. 36. Multispined cells from the foot-pad of a Fly. These are formed by the cytosomes and enable the insect to walk on difficult surfaces.

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Plate XII

Fig. 37. Strongly stained view of the giant spines on the saws of a Locust. The cytosome fibrils show nicely.

Fig. 38. Section of the tracheal tubes of a larva. *Manestra picta.*

Fig. 30. Plastids in the liver of a Spider. Anglena.

Fig. 40. View of the salivary glands of a Katydid. The cell is full of the elaborated cytosome products.

Fig. 41. Binucleated intestinal and fat cells. Hemiptera.

Fig. 42. Cross section of the cytosome fibrils in a Tussock Moth eye.

Plate XIII

Fig. 43. Section of the optic lobe of a Moth, showing the cytosome nerve extensions.

Fig. 44. View of the active extension of the fibrils of brain-cells. The lower part is composed of sections of these cytosome fibrils.

Fig. 45. Section of the rapidly developing eye of a Tussock Moth, five day pupal stage.

Fig. 46. Section of the same Tussock Moth pupal eye at the eight day stage. The magnification is the same in both cases.

Fig. 47. Shows nucleosomes migrating outward and becoming cytosomes. From a Camponotus pupa.

Fig. 48. Shows the cytosomes functioning as nuclei in a new generation of swarm cells. From a fresh water Rhizopod, after Hertwig.

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DEPARTMENT OF NOTES, REVIEWS, ETC.

It is the purpose, in this department, to present from time to time brief original notes, both of methods of work and of results, by members of the Society. All members are invited to submit such items. In the absence of these there will be given a few brief abstracts of recent work of more general interest to students and teachers. There will be no attempt to make these abstracts exhaustive. They will illustrate progress without attempting to define it, and will thus give to the teacher current illustrations, and to the isolated student suggestions of suitable fields of investigation.—[Editor.]

A GIET TO THE SOCIETY

The Society is indebted to Mr. E. W. Roberts for a contribution of $125 to the funds of the Society to defray the expenses of printing the remarkable series of photographs accompanying his article. Mr. Roberts is a photographer as well as an independent student with the microscope, and the Secretary is glad to present his article, not in any sense as the last word on cytology, but as a good illustration of what may be done by the non-professional student, and as presenting an interesting and thoughtful interpretation of some of the facts of cell structure and behavior.

TRYPANOSOME INFECTION AND COMPARATIVE EFFECTIVENESS OF PRIMATE SERUM

Mesnil and Leboeuf (Compt. Rend. Biol., Jan., 1912), in an effort to determine whether the active substances of different serums are identical or related, report somewhat conflicting results. In a first series of experiments, species of trypanosomes were taken which are peculiarly susceptible to baboon serums, and these were found susceptible also to serum of man and the mangabey. Similarly, species only slightly susceptible to one of these serums proved little so to the others; but the degrees of susceptibility were not constant.

This latter fact led to experiments in which strains of trypanosomes were developed, through cultures, to an optimum resistance, which in some instances was 200 times as high as at the outset. With such cultures it was found that the effectiveness of human and baboon and mangabey serums was distinctly different,—the effectiveness decreasing in the order mentioned. It is concluded that the active substances are therefore similar, but not identical, and that the similarity is in some degrees a measure of the closeness of the relationship between these mammals.

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FREE PURE CULTURES OF AMEBÆ PARASITIC IN MAMMALS

Williams (Jour. Med. Research, Dec., 1911) gives a summary of the results of efforts to get pure cultures of amebæ found in human and other mammalian bodies, and to cultivate these without the bacteria which accompany them.

1. Certain strains of such parasitic amebæ may readily be kept going by using as food sterilized brain, liver, or kidney tissue from dogs, rabbits or guinea-pigs.

2. Such artificial cultures do not show essential morphologic variations as the result of this change of regimen.

3. Certain characteristics used by some students as diagnostic of the pathogenic forms (as, large size, motility, highly refractive ectoplasm, weak, chromatin, etc.) are found to belong as well to non-pathogenic forms, apparently; and thus the diagnostic value of these qualities is correspondingly diminished.

4. It is suggested that the amebæ themselves, and not merely the bacteria usually associated with them, may be responsible for amebic dysentery and amebic abscesses.

A METHOD OF DIAGNOSIS IN SYPHILIS

Noguchi (Jour. Exp. Med., Dec., 1911) reports instances of a cutaneous reaction produced in syphilitic patients by the injection of *luetin* (an extract of pure cultures of *Treponema pallidum*), especaily in tertiary and hereditary (latent) cases, which he hopes may prove valuable in diagnosis of this disease,—as supplementing the Wassermann reaction which is more constant in primary or secondary forms.

TREPONEMA PALLIDUM IN MONKEYS

The same investigator (Jour. Exp. Med., Jan., 1912) has inoculated two species of lower monkeys with pure cultures of *T. pallidum* taken originally from human syphilitic lesions. This results in lesions resembling the primary lesions in man and those caused in the monkey by direct inoculation of monkeys with human serum containing the spirochaetes. The blood of the monkeys furthermore developed the property of giving the positive Wassermann reaction. This result verifies the identity of his supposed pure strains with the disease germ, and definitely relates the Wassermann reaction to the *T. pallidum*.

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ECOLOGICAL SUCCESSION OF PLANTS AND ANIMALS

Shelford (Biol. Bull., Dec., 1911) concludes a series of papers dealing with the biological succession in ponds at the head of Lake Michigan. The following are some of the conclusions reached by the author as the result of this series of interesting studies:

1. The quantity of bacteria, plankton, vegetation, and large animals increases with the age of the pond.

2. Terrigenous bottom and oxygen content decrease with the age of the pond.

3. Fish tend to adapt themselves to the type of food rather than to become distributed or furnish successions in accordance with the type of food. They are not necessarily most abundant where food is greatest.

4. Small oxygen content of older ponds will account for absence of fish from them.

5. Conditions outside the breeding season are probably less important than those of this season in determining the success of fish.

6. The conditions most favorable to the normal feeding of fish are not only different from those most favorable to breeding, but are even antagonistic; and the former tend to encroach on the latter. ment, and the preservation of balance between the breeding conditions and the adult life-conditions.

7. Animal succession in ponds is due to an unused increment of excretory and decomposition products which causes increase in vegetation; a decrease in oxygen at the bottom; and a general change in the conditions affecting breeding.

8. Succession of particular species, rather than the continued dominance of some when they once become dominant, results from the inflexibility of their standards of demands in accordance with the changing conditions.

CHROMATIC REDUCTION IN CELL DEVELOPMENT

Rohde (Zeit. Wiss. Zool., 1911) undertakes to show that a marked characteristic of the differentiation and maturing of cells is the reduction of chromatin of the nucleus. He suggests, as illustrative of this, a series with bacteria at one end and the red blood-cells of mammals at the other. The bacteria he considers as prac-

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tically all nucleus. The corpuscles on the other hand have lost their nuclei wholly. Between these extremes we have various stages of chromatin reduction in the development of the specialized Metazoan tissues. The maturation divisions in ova and sperm, the bodily extrusion of chromatin observed on the part of blood-cells, etc., he regards as illustrations of the process.

THE RESERVE OF FOOD IN TREES

Preston and Phillips (Forest Quart., 1911) agree with the common view that starch is the principal form in which reserve food is stored in trees. They doubt that cellulose is able to act at all as a reserve material. The maximum contained reserve for deciduous trees occurs about the time the leaves fall, and during the next few weeks there is a decided reduction in its amount. The sugar content in trees remains pretty constant except for an increase in spring during the unfolding of the buds.

ALTERNATION OF GENERATION IN FLORIDEÆ

Lewis (Bot. Gaz., Mch., 1912), by artificial plantings of tetraspores and carpospores of *Polysiphonia* and some other genera of red algae gets experimental results supporting the general conclusion that tetraspores produce only the sexual plants and carpospores only the tetrasporic plants. In no instance was an exception found to the rule, although a considerable number of plantings developed to maturity. Tetraspores from a given individual produced male and female plants in approximately equal numbers. It is also concluded that no greater growth vigor comes to the carpospores over the tetraspores because of the double number of chromosomes contained by them.

RELATION OF THE PROTOPLASM OF ADJACENT PROTOPLASTS

Thoday (Ann. Bot., 1911) undertakes to throw light on the relation that exists between protoplasms of contiguous cells, by an examination of the relation between the parasite, *Cuscuta,* and its host. She finds that there is no direct protoplasmic connection between the cells of *Cuscuta* and the host, but that the phloem cells of the parasite haustoria apply themselves to the sieve plates of the phloem of

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the host. The wall of the former breaks down over the area of contact, but the protoplasmic threads do not penetrate and become continuous with the protoplasm of the seive cells. The parasite seems to receive the food passively through the action of internal pressure in the cells of the host.

The author suggests that this study appears to lend support to Gardiner's view that connecting threads of protoplasm, as found between the cells of some plants, represent original connections between genetically connected cells due to lack of complete dividing walls along the plane of division, and are not secondary connections of the protoplasts effected by the cell walls being perforated by advancing protoplasmic fibrils.

A NEW FORM OF PARASITISM

Jensen (Ann. Jard. Bot. Buitenzorg, 1910) reports the study of several species of dipterous larvae, belonging to not less than three different families, that are able to live in the mixture found in pitchers of *Nepenthes*. They are able to resist the action of the ferments secreted by the *Nepenthes*, which digests the other contained organisms. He found that closely related larvae taken from nearby waters were wholly unable to withstand the action of the fluid. These conditions seem quite analogous to those encountered and overcome by some intestinal parasites of animals.

BACTERIA IN RIVER WATER

Reiss (Verh. Phys. Med. Gessell. Wurtzburg, 1911) reports the finding of as many as sixty-two species of bacteria in samples of river water taken from the Main, near Wurtzburg. On cultivation, a number of species showed resemblances to known pathogenic types, but seemed to have lost their virulence. This is certainly a remarkable showing of bacteria.

CONDITION OF CONTINUOUS DIVISION IN PARAMECIUM

Woodruff (Biol. Bull., Dec., 1911) believes that most, if not all, normal individuals of Paramecium, under suitable environmental conditions, possess unlimited power of reproduction without conjugation or artificial stimulation; and that the discrepant results of dif-

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ferent workers are possibly due to undetermined and unmet variations in the cultural demands of the various strains isolated for study.

THE COCKROACH AS AN AGENT OF CONTAMINATION

Morrell (Brit. Med. Jour., 1911), through experimentation with the feces of the cockroach, discovers that it is to be regarded as a significant carrier of disease in addition to being a general nuisance. He reports that the feces will produce souring of milk; carry various intestinal bacteria; transmit tubercle bacilli; transmit disease producing cocci; and carry various molds.

BUSHMAN'S POISON FOR ARROW HEADS TAKEN FROM LARVÆ

Trommsdorff (Archiv Schiffs- u. Tropen-hygiene: Heft 19; Band XV., 1911) while on an expedition in the Northeast part of German S. W. Africa, was told by a native that the Kalahari bushmen, in addition to using the vegetable juices, also obtain a poison for their arrow heads from certain larvæ. By bribery the native was persuaded to show how and where the larvæ were obtained. The native took him to a large hole under a bush and in a few minutes dug up several brown sandy objects about the size of a hazel nut. When broken open each contained a yellowish, curved larva with two pairs of legs. Trommsdorff was not able to experiment then, but in November, 1910, he obtained a supply; made an emulsion with salt solution and injected this into a number of animals. The effect on dogs was to cause a localized oedema at the site of injection, acute inflammation of all internal organs, dyspnœa, and death in 16-18 hours. Experiments are fully reported in the original article.

ANOPHELES

Anopheles and anopheline, as signifying a particular kind of mosquito, are words in daily use, and are often pronounced wrongly. The error lies in giving the *o* a short value instead of a long. The users of these terms forget that they are derived from the Greek, and the *o* is an omega and not an omicron. Therefore anopheles or anopheline should be pronounced anōphĕlēs or anōphĕline; not anŏphĕlēs or anŏphĕline. Curiously, the people who mispronounce these words as regards the *o*, give the correct quantity to the two *e's* in anopheles. They recognize the first *e* to be an epsilon or short *e*, and the second to be an eta or long *e* in the word anopheles; and the *e* in anopheline always to be short.—(J. R. A. Med. Corps., Jan., 1912.)

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MODERN MICROSCOPY

It is no longer possible for the publications of the American Microscopical Society to give the space which was given in the early years of the society to technic of microscopy; nor is it necessary. The great majority of the members of the society are well versed in the possibilities of the miscroscope and in the methods preliminary to its use; and students in colleges and universities have regular courses given to the subject. Furthermore, the independent amateur can, for a dollar or two, secure any one of several books which will give more satisfactory service to the beginner than could possibly be given by a journal such as this.

The fourth edition of such a book has recently been issued. It contains in compact compass such instructions as will enable the beginner to select an outfit and to proceed with its use in an intelligent way.

Parts I and II, contained in earlier editions, are here enlarged and brought up to date. Part III is new, and will prove extraordinary value to the independent student.

Part I, consisting of five chapters, deals with such subjects as the microscope, its construction, the facts about the optical parts, illumination, accessory apparatus, principles to be held in mind in the choice of an outfit, and the like. Part II deals with the principles underlying the general technic of preparing materials for microscopic examination and the application of these principles to special cases. It comprises fifteen chapters. Part III, which is new, is really a series of condensed articles by experts on a number of topics of special interest to the amateur student. One can easily wish that other similar chapters on other groups of objects might have been added. These chapters are: Introduction to Use of the Petrological Microscope, by Frederic J. Cheshire; Rotifera, by C. F. Rousselet; Mites Found in Fresh Water, by C. D. Soar, one of our own honored members; Collection and Preparation of Foraminifera, by Arthur Earland; Collection and Preparation of Mosses and Liverworts, by T. H. Russell; Microscope and Nature Study, by W. M. Webb; The Microscopy of Foods, by Cuthbert Andrews. As might readily be expected, these chapters are somewhat uneven in quality. The writers are English and the book is written from the English

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point of view. This does not interfere with its suggestiveness to American students, although it will necessitate certain adjustments in the chapters involving English fauna and flora.

Modern Microscopy. A Handbook for Beginners and Students. M. I. Cross and M. J. Cole. 4th Edition. Chicago, 1912. Chicago Medical Book Co. Price $2.00.

LABORATORY DIAGNOSIS

In Professor Todd's recently issued second edition of "Clinical Diagnosis" there is an extraordinary amount of material interesting not only to the physician but to the general student with the microscope. It is at once a clear and a concise presentation of the microscopic and chemical study of disease.

The general chapters relate to examination of sputum; of urine; of blood; of stomach contents; of feces; miscellaneous examination, including pus, mouth, eye, ear, skin, milk, etc.; animal parasites; bacteriological methods; preparation and use of vaccines; apparatus and reagents.

The mere enumeration of these chapters does little toward giving the reader a conception of the exceptional richness of the contents nor is it possible in the limits of this review to do more than suggest this. The revision contains all the essential matter of the first edition and introduces, among many other things: a discussion of the use of artificial light with the microscope; simple apparatus for photo-micrographic work; the antiformin method for detection of tubercle bacilli; detection and significance of albumin in the sputum; Tsuchiya's modification of Esbach's test for quantitative estimation of albumin in urine; Benedict's methods for determining quantity of sugar in urine; Wright and Kinnicutt's method of counting blood platelets; Harlow's blood stain; a simple technic for diagnosis of typhoid fever by blood cultures; the Wassermann reactions for testing syphilis, and Frothingham's impression method for the detection of Negri bodies in rabies.

The chapter on the animal parasites has been rewritten and enlarged; and a general chapter on bacteriological methods and one on preparation and use of vaccines have been added. The discussion of parasites in relation to human diseases takes on new significance in the light of recent progress in the study of such parasitic diseases as malaria, syphilis, relapsing fever, the numerous tropical trypanosome diseases, hookworm disease, and others. The book will prove,

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as has its predecessor, a most valuable manual in the hands of all physicians who use the microscope in diagnosis, and almost in equal degree a valued book of reference for the general student with the microscope.

Clinical Diagnosis. A Manual of Laboratory Methods. James Campbell Todd, M.D., Professor of Pathology, Univ. of Colorado. Revised Edition, with 469 pages and illustrations. Philadelphia and London. W. B. Saunders Co. 1912. Cloth $2.25 net.

THE HOUSE FLY: DISEASE CARRIER

Dr. L. O. Howard, in a volume with the above title, undertakes to bring to public attention, in a readable form, the principal facts underlying the warfare that needs to be waged against the "Filth" or "Typhoid" fly. The author disclaims the purpose of producing a scientific monograph; but the book is really a monograph on the fly as related to human life. The chapter headings are as follows: Zoological Position, Life History and Habits; The Natural Enemies of the Typhoid Fly; the Carriage of Disease by Flies; Remedies and Preventive Measures; Other Flies Frequenting Houses. There are also a number of appendices giving bibliographical lists and extracts of articles by Dr. Howard and others on the flies frequenting human and other excrement, on regulations of the Health Department of the District of Columbia relating to house flies, on directions for building a sanitary priviy, on disposal of night soil.

In addition to the general interest in the subject because of its practical importance to dweller in town and country alike, one chapter particularly furnishes matter which should be of special interest to microscopists. This is Chapter II, dealing with the natural enemies of the fly. Those readily lending themselves to study by the general student of the microscope are: Fungous parasites (chiefly three species of *Empusa*) in the soft tissues; Protozoa in the digestive tract; nematodes in the proboscis and in and about the head; mites which attach to the surface of the flies; and a number of parasitic insect enemies.

The figures illustrate a number of species of common flies.

The House Fly: Disease Carrier. L. O. Howard, 312 pages; illustrated. New York 1911. Frederick A. Stokes Co. Price, $1.95 postpaid.

THE SPIROCHETES

The peculiar interest which has recently attached to Spirochetes grows chiefly out of the brilliant series of scientific investigations,

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beginning with the discovery by Schaudinn in 1905, showing that *Treponema (Spirochaeta) pallidum* is definitely responsible for the lesions occurring in syphilis, and leading to its isolation, identification, and control.

In addition to this they have considerable claim to biological interest because of their apparently intermediate position between bacteria and protozoa.

Dr. W. Cecil Bozanquet, of the Royal College of Physicians of London, has recently brought together in a small book of two sections the matter of chief biological interest to the student. In Section 1 are discussed such topics as their biological position, morphology, habitat, cultivation, multiplication and development, association with other organisms, pathogenic qualities, methods of staining and examination. In Section 2 is given a systematic description of the known species, together with illustrations.

In his summary of the phenomena of pathogenicity of the Spirochetes the author classes them in three classes with ascending degrees of virulence: (1) those of slight virulence producing a local affection or lesion only; (2) those in which there is a well marked local lesion, followed by a generalized infection, with relapses not a marked feature; and (3) those of most intense virulence producing immediate generalized septicæmia, accompanied by fever, tendency to relapses, and enlargement of the spleen. In the second group would come those associated with yaws and syphilis; and under the third, those causing the relapsing fevers, fowl-spirillosis, etc.

The author's work was evidently done before the isolation of *Treponema pallida* and recent demonstration of the causal connection between it and syphilis.

Spirochaetes. W. Cecil Bosanquet, M. D., octavo of 152 pages, illustrated. Philadelphia and London. W. B. Saunders Co., 1911. Artistically bound, $2.50 net.

PELLAGRA AS AN AMERICAN PROBLEM

Dr. George M. Niles, in a book of 250 pages, undertakes to give a readable account of this apparently modern disease. The effort is a timely one in America, in the light of the great increase in the recorded instances of the malady in the United States.

The following chapter headings will indicate the order and scope of the treatment: General Historic Considerations; Pellagra in the United States; The Etiology of Pellagra; Symptomatology and Clin-

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ical Course; Pathology and Morbid Anatomy; Diagnosis, Course, and Prognosis of Pellagra; Treatment of the Disease; Prophylaxis; Description and Discussion of Some Recent Experiments on Animals. There is an index of authors and of topics. The earliest accounts, which may possibly relate to pellagra, are not certain; but it is suspected among the American Indians as early as 1600, and even then was believed to be related to the use of Indian corn. From this time forward, under different names, and in different countries, records appear which seem to indicate pellagra. Not until 1863 do we hear definitely of it among the whites of America. There has been since that time a gradual accumulation of data, and apparently an increase of the disease itself, until at the present time the author believes that there are from 6,000 to 10,000 cases in the United States.

The author quotes liberally from the various students of the etiology of pellagra and presents the various views, which may be classified as follows:

A. Those which hold that it is wholly unconnected with Indian Corn, but caused by some parasite with seasonal periods of activity and latency. (Dr. Sambon.)

B. Those holding Indian Corn responsible for the disease.

I. Through good corn, even.

1. Because it lacks some necessary nutritive property.

2. Because it contains some toxic substance which tends to cause the disease.

II. Through spoiled corn only.

1. Because of toxic substances produced by the spoiling of corn or by the action of organisms in it. (Lombroso.)

2. Because of the direct conveyance to the human system of organisms that in turn produce directly or indirectly the disease.

The author believes that the malady is related to spoiled corn (toxins produced therein). The prophylaxis must necessarily be uncertain until the etiology is determined but in the meantime it is certainly a part of the duty of governments to see that meal made of moldy corn is not distributed to consumers.

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There is no evidence that it is or has been seriously considered to be contagious. The principal suggestions cluster about inspection of corn and corn products and the prohibition of commerce or use of spoiled corn.

Pellagra. By George M. Niles, M. D., Atlanta School of Medicine, 252 pages, illustrated. Philadelphia and London; W. B. Saunders Co., 1912. Cloth, $3.00 net.

INJURIOUS INSECTS

Dean E. W. Sanderson has given us a most beautifully illustrated account of the principal insect pests. The illustrations are drawn from the most varied and authoritative sources. The text is in most places clear and direct, and the book is eminently readable. On examining it one is at once impressed with the marvelous value of co-operation in scientific work. Here are gathered from all quarters the results of the most laborious and painstaking work of hundreds of scientific men all over the country. It seems like the work of one man, and is ready for the common man to utilize.

There are twenty-eight chapters. The book begins with a general chapter on "Injury to Crops by Insect Pests," in which it is estimated that the annual damage done by insects in the United States is as much as $1,000,000,000. An analysis is made of this total as it affects the various types of crops. A chapter follows on "Beneficial Insects," in which the work of predaceous forms, such as the ladybird beetle, and of parasitic types, is described. There are three chapters on control of insect pests, insecticides, spraying and the like.

The body of the book consists of a discussion of the insects injuring the special crops: as small grains; corn; stored grains; clover; tobacco; cotton; hop plant; potatoes and tomatoes; beans and peas; beets and spinach; cabbage and cruciferous plants; melons and squash, etc.; sweet potatoes; strawberry; raspberry and blackberry; currant and gooseberry; grape; orchard fruits (3 chapters).

It is difficult to see how this matter could be put into form more available for the general reader and student. It furnishes an excellent starting point for the amateur student with the microscope, as well.

Insect Pests of Farm, Garden and Orchard. E. Dwight Sanderson, Dean of College of Agriculture, W. Va. Univ.; 684 pages, 513 illustrations. New York; John Wiley and Sons, 1912. Price, $300 (12/6) net.

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INDEXING AND FILING METHODS FOR THE MICROSCOPIST

Text:—The next best thing to knowing a thing is to know where it can be found when wanted.

Application of the above text by an amateur Microscopist:

1. *Filing Brief Articles.*

The amateur, especially if he is working alone, groping in the dark, as it were, must depend upon what has been done by others for his start and early ideas, to a great extent, and this knowledge must be gained from their published work usually. A great deal of this work was done during the years 1840 to 1880, when the "battle of the lenses" was waged, and great interest was taken in the resolution of the markings on diatoms, etc. Great interest was also taken in general microscopy during this period and the results are found in the papers, periodicals, etc., published on the subject during that time.

The writer endeavors to obtain as many of these periodicals, etc., as possible, and after looking them over removes the pages containing such articles as he wishes to preserve. If an article occupies two or more leaves they are kept together by placing three "dabs" of mucilage near the top edges and pressing them together. These articles are then filed and indexed by the vertical filing system. Excellent equipment for this system can be purchased, but they are quite expensive, and the plan adopted by the writer is as follows: Folders are made from sheets of Manila paper heavy enough to stand alone and 17½ inches long by 13 inches wide, which are folded so that one end projects ½ inch beyond the other. This projecting end is then cut so as to leave a tab on which to write the subject of the contents of the folder. These tabs have a length equal to one-third the width of the folder, which is 13 inches. Part of the folders have this tab located in the middle of its width, part of them have it even with the left hand edge and the remainder have it even with the right hand edge. We now have vertical folders 13 inches wide by 8½ inches deep, with a half inch tab on the top edge.

Twenty-six of the folders having the tabs even with the left hand edge are then marked with a letter of the alphabet and stood on

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edge in a drawer or box 9½ inches deep by 14 inches wide and as long as the user wishes.

The articles taken from the periodicals are now placed in the folders according to their subject matter, which is written on the tabs. The folders are now arranged behind their proper alphabetical index folders first placed in the drawer. These index folders act as alphabetical guides and in them is also placed articles on a subject which at first may not seem of sufficient importance to call for a separate folder.

In cutting out articles from periodicals, etc., as above described there will be cases where the last page of the last leaf of the article clipped contains the beginning of an article on another subject which it is also desired to keep. In this case the writer proceeds as follows: The most important article is given the preference and filed in the proper folder, then in the folder having the tab bearing the subject of the other article is placed a sheet on which is written the title of the second article and a note to the effect that it is on back of such an article—naming the title of the first article. In this way cross references can also be made, so that it makes a very complete system. There is no pasting required, except the "dabs" spoken of above; the contents are already indexed when the folders are properly placed, so no card index is necessary and the space occupied is limited only by the size and number of boxes or drawers called for.

While the above sounds complicated, it is in fact very simple; the secret of satisfaction with it lies in filing material away as fast as it collects rather than allowing a lot to collect before placing it in the folders.

The writer uses the above method for pamphlet, specimen pages and reviews of books, photographs, sketches; in fact, anything of that character can be placed in the file and readily referred to.

2. *Card Index for Notes.*

The writer also makes great use of the card index and is a firm believer in its value in nearly every profession. The regular size cards, 3x5 inches and 4x6 inches, are the ones used, with arrangement of rulings to suit the case.

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CARD "A"

Zoo.	Zoology
375	An Inroduction to Zoology.
	R. W. Hegner (Univ. of Mich.)
	,Macmillan Co., N. Y.
	Oct. 1910. 8 vo.-ils.-cloth-425 pgs.-1 vol.
	$2.50 net.

In order to show the working of the system as used by the writer we will assume that a catalogue or notice has been received from an agent or publisher regarding a book on Zoology. The book is entered on card "A" for future reference. Later on the book is purchased and entered on card "B," being given the number 375, which is the next consecutive number under "Bibliography," which comprises all books, periodicals, papers, and everything of a like nature in which the writer is interested or has brought to his notice. The number 375 is merely for use in referring to matter in that book and is now entered on card "A," as shown.

CARD "B"

Bib.	Bibliography
370	
371	
372	
373	
374	
375	An Introduction to Zoology—Hegner.
376	
377	
378	
379	

Cards "A" and "B" form an index on Bibliography and if desired a third card may be used which would be an author's index, for the purpose of keeping all of the writings of an author together and on which the entry would be as follows:

Hegner, R. W.

375—An Introduction to Zoology.

Other works or papers by Hegner being added as they appear from time to time.

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We will say in perusing the book we found a description of the odontophores of mollusks and directions for preparing and mounting them, and, wishing to make a note of it, we fill out card "C," the "No. 375, page 253," indicating the reference and page on which the information is found. The writer uses card "C" in a card index of notes on technique, general information, etc., and it is of great use if it is desired to compose a paper or anything of that sort on a certain subject.

CARD "C"

Odo.	Odontophores
	(Here follows such notes, etc., as is desired
	for this place, the numbers (375) giving the
	reference, where more complete informa-
	tion may be found if desired.....
	.....375 page 253)

Later on we find a mollusk and, wishing to prepare a slide, refer to card "C," and the result is card "D," on which is filled in the information indicated. The number 750.375 is a system of classification similar in principle to the Dewey classification of literature, applied to this subject. The integral part of the number showing whether it belongs to the animal, vegetable or mineral kingdom, also the particular division of the kingdom, and the decimal part showing which part of the system it relates to—nervous, circulatory, etc.—in case it is of the animal kingdom.

CARD "D"

750. 395		Odontophore—(Name of Mollusc)
Kill	Medium	Directions—duration, notes, etc.
Fix.		
Wash		
Stain		
Harden		
Dehud.		
Imbed		
Clear		
Mount.		
Section thickness		Cover glass thick: Date.....

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One frequently runs across information when away from home and laboratory so that it is necessary to make notes and transcribe them to cards upon arrival home. To overcome this, the writer, instead of using the ordinary notebook, uses the "National Simplex Memorandum Book No. 4450," partly filled with quadrille ruled leaves for ordinary notes, sketches, etc., which is for temporary use. The remainder of the filling consists of 3x5 inch index cards perforated to match the regular fillers. The necessary notes, sketches, etc., are made on these cards, which are placed in the regular indexes upon arrival home and fresh ones placed in the memorandum book. He also uses a similar book, No. 4480, for the 4x6 inch cards and finds this system of keeping notes very satisfactory indeed; far better than the bound notebooks.

The professional will probably condemn all of the above as being too complicated and requiring too much valuable time, and it would be quite a task for him to file and index the material he has collected during a number of years of professional life, although it would be well worth the trouble.

If the beginner will adopt the above system or such modification of it as best meets his wants he will never regret it and every year adds to its value to him.

In order to show how the value of the system may be more fully realized let us assume that it has been quite generally adopted by others interested in Microscopical work and that the writer runs across some subject requiring special technique or processes with which he is not very familiar. He applies to the society of which he may be a member, or to friends interested in a similar line of work, for information on the subject. They look over their indexes and, finding the object sought, make out a copy of their cards and send to him. He uses the information and places the card in his index for future reference. If they do not find the actual information on their cards, they may find a reference in their index of "Bibliography" as per cards "A" or "B," which will tell the inquirer where the information may be found.

Such an interchange of card index information would prove of mutual benefit to fellow-workers and especially isolated workers like the writer.

Geo. H. Marr,
Waterville, Maine.

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HOW TO DETERMINE THE PRESENCE OF INTESTINAL PARASITES

Darling (Société de Pathologic Exotique, May 10, 1911) describes two simple methods for determinining the presence of intestinal parasites, especially the oxyuris, *Ankylostoma duodenale* and the *Strongylus stercorale.*

The first method consists in mixing a small portion of the feces with sterile water in a Petri dish and incubating at 37 degrees for twenty-four hours.

The second method is based upon the separation of the ova by means of centrifuging. The specimen is shaken vigorously in a test tube with sterilized distilled water, then centrifuged after calcium chloride has been added. The supernatant fluid is then examined for the ova.—(V. A. L., in *La Tribune Med.*, Mch., 1912.)

EXAMINATLON OF SPUTUM FOR TUBERCLE BACILLI

Many methods have been tested by which sputum may be liquified and the bacilli precipitated, and the use of the centrifuge and filter dispensed with. The following are presented by Nemmser and Martos-Lissowska (Deutsch Med. Woch., Sept. 14, 1911; p. 1697);

(1) *Alkaline trypsin digestion.*

To 0.1 cc. of trypsin and 5 cc. of a 0.4% sodium hydrate solution are added 5 cc. of sputum. Shake the mixture with the addition of a few drops of $CHCl_3$ and incubate at 37° C for 24 hours. Then there will be found beneath a clear supernatant liquid, a *compact* deposit, which can be readily removed and stained.*

(2) *Acid trypsin digestion.*

As above; except that 0.4% HCl is substituted for the soda solution, and no $CHCl_3$ need be added.

(3) *Oxidation.*

To 5 cc. of sputum 5-10 drops of perchloric acid—$HClO_4$—and 5 cc. of water are added. This is incubated, and treated as before. Instead of the perchloric acid, 0.5 grm. of potassium chlorate and 5 cc. of 0.4% HCl may be substituted.

*Much's method of sputum staining is very valuable for all suspected cases of phthisis in which no tubercle bacilli are found by the usual methods of examination. This consists of treatment with anilin gentian violet for 48 hours and then with Gram's solution. By this means non-acid fast forms of tubercle bacilli, which fail to retain the dye under Ziehl's process, may be seen. See Roepke, Deutsch Med. Woch., Oct., 1911, p. 1937, or J. R. A. and Med. Corps, Mch., 1912, p. 357.

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The sediment obtained by these methods is more abundant, and can be fixed to the slide more easily than that which is deposited by antiformin. Tubercle bacilli were found by these methods 21 times in 300 examinations, in which they would otherwise have escaped detection.

DETECTION OF TYPHOID BACILLUS IN WATER

A method is reported (Lemke: Deutsch Med. Woch., Sept., 1911; p. 1698) based on the fact that the bacilli are inhibited to a less degree by a strongly saline fluid than are water bacteria. Add 3-5% sodium chloride to peptone broth of + 10 to + 25 acidity to phenolphthalein. He prepares a watery solution of malachite green Merck Ia, 1 in 120: 0.2 cc., 0.3, 0.5, 0.7, 1.0, 1.4 cc. of this are mixed with quantities of 100 cc. of the salt broth. 15 cc. of each are placed in tubes, which are then inoculated with the suspected water. He has recovered the typhoid bacillus in 60 experiments after artificially contaminating the water,—in one instance when only 2 typhoid germs were introduced.

BUTTERFLY SCALES

B. Braman of the N. Y. Micros. Soc. proposed the following excellent method in 1881:

Dissolve 1 part of Anthony's "French Diamond Varnish" in 2 parts pure benzole. Apply a drop or two of the solution to a slide. In a few seconds, or as soon as varnish has set, press the wing of the moth or butterfly gently upon the slide and then carefully lift it away. The transfer of the scales shows a beautiful natural arrangement on the wing. Make a shallow cell around and apply cover. Canada balsam must not be used, as it disarranges the object.

CINNAMON OIL FOR EXAMINING ROUGH MINERALS FOR INCLUSIONS, FLAWS, ETC.

By applying a few drops of the oil to the surface of a transparent mineral, it is possible to examine the interior for inclusions, flaws, etc., without grinding the surface flat. Sand can also be examined for inclusions under the microscope.

ARRANGING AND MOUNTING SCALES OF INSECTS AND DIATOMS, ETC.

Use liquid gelatin thinned with an equal volume of 50% acetic

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acid. Spread a *very* thin coating on slide and let dry; place the object on; breathe on it very gently to soften the gelatin and to allow adhesion of objects. If carefully done it holds well.

SIMPLE DRAWING APPARATUS

A very useful accessory in micro-biological work is announced by Baush & Lamb Optical Company. It is designed for drawing from microscopic specimens, where magnified images of from 50 to 430 diameters are desired, the full diameter of the image circle being utilized for all magnifications within that range. It enables one to work with the eye at its normal reading distance from the pencil, a feature greatly appreciated by one doing much work of this character.

The apparatus is very simple but accurately constructed, and is thoroughly satisfactory in use. Adjustments are reduced to a minimum, the standard image distance of 250 mm (10 in.) from mirror to drawing surface being fixed It is designed to accommodate almost any standard microscope.

The following detail of the makeup of the apparatus will make clear its character:

Microscope Support—Of wood, substantially constructed and neatly finished permanently attached to base, which is one piece, with drawing board top surface 128x175 mm, height 90 mm, assuring standard image of 250 mm with microscope in position; provided with simple metal clamp to hold microscope rigidly in place.

Drawing Board—Provides smoothly finished drawing surface 282 mm (11⅛ in.) square, with light shield in position.

Light Shield—Sheet metal, neatly finished in black to avoid reflections; of a size and form to shade effectively three sides of the drawing surface.

Mirror—50 mm in diameter hinged, with stop at angle of 45 degrees to direct image perpendicularly to drawing surface; mounted on metal clamp which can be readily attached to microscope draw tube in any desired position; mirror can be raised for changing eyepieces without removing.

Lamp—Special hand-feed 90 arc, protected by metal hood having small observation window; provided with bulls-eye condenser,

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adjustable in tube for giving parallel or converging beam of light as desired; entire lamp mounted on support and adjustable vertically and laterally.

Rheostat—Of fixed form, accommodating 110 volts; 5 amperes of current must be used with arc lamp to regulate the current.

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NECROLOGY

DR. SETH G. SHANKS

Dr. S. G. Shanks, a member of the American Microscopical Society since 1900, died Nov. 5th, 1910. He was an expert and devoted microscopist, and gave much time to the preparation of microscopic slides. It is an interesting coincidence that the illustrations of Mr. E. W. Roberts' paper, published in this number, are photographs of sections made by Dr. Shanks.

Dr. Shanks was a student under Dr. James Armsby and graduated from the Albany Medical College in 1875, taking the prize for the best thesis. After a year of hospital work he entered upon private practice.

His acquaintances testify that he was a most charming companion, and, while he was of a very retiring disposition, he endeared himself to all those who came close to him.

Mrs. Shanks and their daughter survive him.

ROBERT BROWN

Mr. Robert Brown, of New Haven, Conn., a member of this Society since 1885, and a Life Member since 1903, Secretary Emeritus of the Yale Observatory, died June 11, 1911, at the home of his sister.

The cause of his death was gradual weakening of the heart. He was born March 8, 1836, in Cincinnati, Ohio, where his father was a business man who came to this country from Scotland in 1830. He prepared for college under Charles Mathews, principal of a private school in Cincinnati, but on account of ill health did not enter Yale until the third term of Freshman year. During Sophomore year he

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was largely instrumental in obtaining the first gymnasium, on Library street, and in college was a member of Linonia, Psi Upsilon and Scroll and Key. After graduation he spent one year at the Yale Medical School for the study of comparative anatomy, but the following year he returned to Cincinnati and was associated with his father in business until 1866. He then became assistant secretary of the Cincinnati Gas Light & Coke Company, and subsequently filled the positions of secretary, treasurer and vice president, remaining with the company sixteen years. Soon after the organization of the new astronomical observatory at Yale, he accepted the newly created office of secretary of that department, which he held until his resignation in 1907, at the close of twenty-five years of service.

At a meeting held at Cincinnati in 1864 to draft resolutions relative to the death of Professor Silliman he advanced a proposition which led to the formation of a Yale Club, believed to be the first one ever organized, of which he became the first secretary. In 1861-62 he was treasurer of the Young Men's Mercantile Library Association of Cincinnati, and its corresponding secretary for the succeeding two years. From 1863 to 1883 he was director and treasurer of the Theological and Religious Library, of which he was a life member; he was manager of the Cincinnati Public Library from 1864 to 1869; member of the School Board of Cincinnati, 1864-65, and corresponding secretary of the Cincinnati Horticultural Society from 1859 to 1868. He was a member of the National Conference of Charities and Corrections, and of the Mohonk Indian Conference; a member and fellow of the American Association for the Advancement of Science; a life member of the Historical Society of New Haven, of the American Forestry Association, of the Yale University Club, and of the Appalachian Club. He was a member of the Country and Graduates clubs of New Haven, as well as a charter member of the Yale Club of Cincinnati. He was married October 2, 1860, to Miss Caroline P. Root, who died October 28, 1908. Two children (adopted) survive, Mrs. Flora C. Fullerton and Mrs. Jessie S. MacFarland.

[Thru the Courtesy of the *Yale Alumni Weekly*.]

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JULY
1912

VOLUME XXXI No. 3

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TRANSACTIONS
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Vol. XXXI JULY, 1912 No. 3

A BACTERIAL CANKER OF PLUM TWIGS

By I. M. Lewis

A disease of plum trees popularly known among growers as canker was first called to my attention during the summer of 1910. Since that time it has been kept under observation and has been found to be one of the most prevalent and serious diseases of the plum which occurs in this area. It was first reported from this locality by Heald[1] and Wolf in their report of the diseases prevalent in the vicinity of San Antonio, Texas, and a brief description of the symptoms was here given. These writers made collections in several different orchards and reported it to be the cause of much damage. The same disease had been previously recorded by Heald[2] in 1905 from Nebraska. A similar and perhaps identical disease was reported from Delaware in 1905 by Jackson[3], and the statement made that it causes considerable damage to the plum orchards in that section of the country. These reports were all based upon incomplete studies but agree very well in the description of the symptoms, the seriousness of the disease, and the probable bacterial origin of it. A careful search through the literature failed to reveal more information concerning this canker than is contained in the notes cited above. It seemed therefore, that in view of its widespread

1. Heald F. D. and Wolf F. A. A Plant disease survey in the vicinity of San Antonio, Texas. Bulletin U. S. Department of Agriculture, Bureau of Plant Industry, 226:32. 1912.

2. Heald, F. D. Annual Report of the Nebraska Agricultural Experiment Station, 19:32-33. 1905.

3. Jackson, H. S. Bacteriosis of plums. Annual Report of the Delaware Agricultural Experiment Station, 18:75-76. 1905.

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distribution and unknown etiology, a careful study including cultural work and inoculations should be carried out. Accordingly at the beginning of the present season such a study was undertaken.

Symptoms

The first visible indication of a young canker is the appearance upon the wood of the first season's growth of a small water-soaked spot surrounding a lenticel. Such a spot enlarges rather slowly and the tissue immediately surrounding the lenticel becomes slightly bulged outward due to the great numbers of bacteria which have multiplied in the underlying tissue. As the spots increase in size, they soon became much longer than wide, frequently reaching a length of one to three centimeters. The twig may be completely girdled but this is not generally the case. In the majority of the cankers about one-half the diameter of the twig is involved. The infected areas always become more or less sunken with age and the color changes to a purplish black with a transluctent border. It frequently happens that several of these areas become confluent, producing a very much elongated area, and one which encircles the twig completely and kills it.

These sunken areas, show in cross section, a number of radial rifts or cavities extending outward in the young wood and cortex to just below the epidermis. As the twig increases in size, these rifts open to the outside, forming a medium longitudinal fissure. The cankered tissue contains great numbers of bacteria which may be frequently seen to form a bacterial ooze. The new cankers never appear upon any of the wood except that of the first season's growth. Twigs have been observed upon which a dozen cankers were present in different stages of development. These Cankers do not generally become healed over but persist on the twigs of the second and succeeding seasons as open perennial cankers.

When once a tree has become invaded, and the diseased branches permitted to remain in the tree, it would require the most drastic pruning to remove all of the diseased wood. In many cases the tree is so badly damaged as to render its complete removal advisable. The older branches shown in the accompanying plate are six years old.

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The Causal Organism

The organism which causes the disease is readily isolated from the underlying wood and cortex of young unopened cankers. Such tissue was removed by means of a sterile scalpel, placed on a sterile glass slide in a few drops of bullion, and teased apart so as to secure a suspension of the bacteria. Dilutions were made from this into plain agar in the usual way and series of plates poured. Several such isolations were made. In every case where the young unopened spots were employed the cultures secured were so nearly pure that there seemed little doubt that the prevailing organism was the one responsible for the cankers. The second and third plates of a series were frequently secured containing fifty to two hundred colonies without a single contamination. The colonies do not develop at a temperature of 37° but are visible at 25° after forty-eight hours. The surface colonies are almost white at first, translucent, moist and glistening. They later become distinctly yellow and reach a diameter of one to five millimeters. The deep colonies are lenticular and darker in color. In hanging drops, the organism was found to be a small actively motile, rod-shaped form occurring singly or in pairs, or occasionally more than two together. The organism grew well in all the different kinds of culture media in which it was tried.

Cultures five days old grown upon sloped agar were used in making the inoculations. A number of young plum trees growing in pots in the greenhouse furnished the material for the inoculations. These trees bore young rapidly growing shoots a foot or more in length and the leaves were young and tender. Sterile water was added to the agar tubes and the growth removed by means of a sterile needle was completely mixed with the water, and then transferred to an atomizer and sprayed upon the young twigs. These trees were then placed in a dark room and covered with bell jars where they remained forty-eight hours. They were then removed to the green house in which the atmosphere was moderately humid and remained here throughout the experiment. Control plants were sprayed with distilled water and otherwise treated in exactly the same manner as the inoculations.

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The first visible results of the inoculations was the appearance of numerous, small, water-soaked spots on the young leaves near the tip of the branches. These spots began to appear about two weeks after the inoculations were made. They soon changed in color to a purplish black and a microscopic examination revealed the presence of great numbers of bacteria within the tissue. Isolations from the leaf spots yielded pure cultures of the same organism that had been isolated from the twig cankers and sprayed upon the leaves. The leaf-spots were also apparently identical with the "shot-hole leaf-spots" of plums described by Smith[4], and caused by Pseudomonas pruni. The appearance of the water-soaked areas upon the leaves was accompanied by the development of a few upon the twigs, but they were not present here in anything like the great numbers which appeared on the leaves. They were, however, identical with the young cankers which develop in the field under natural conditions.

A number of the young twigs were next inoculated by means of punctures. A sterile teasing needle was used in making the puncture and then some of the bacteria were introduced into the wound. These plants were treated in exactly the same manner after inoculations as the sprayed plants. They were sprinkled well and kept in the dark under bell jars for forty-eight hours and then removed to the greenhouse. Control twigs were punctured, sprayed with tap water, and treated otherwise in the same manner. The punctures of control twigs, afer removal to the greenhouse, soon became dry and there was never any indication of infection. The inoculations were almost without exception surrounded by the characteristic water-soaked tissue within a few days and in due time typical cankers developed. Similar inoculations were made with young peach trees, and in this case also the punctures were almost uniformly successful.

With the successful isolation of the organism and the artificial production of the cankers by it, the question arose as to its identity. The fact that the organism is capable of producing a leaf spot that is in all ways apparently identical with the "shot-hole" spot already

4. Smith, Erwin F. Obervations on a hitherto unreported bacterial disease, the cause of which enters the plant through ordinary stomata. Science N. S. 17:456-457.

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widely known, suggests the probability that the organism which causes the cankers is identical with Smith's Pseudomonas pruni. The orchards from which the original isolations were made were carefully examined in order to determine the prevalence of a leaf-spot, and whether the black spot of the fruit was present or not. The shot hole spot was found to be abundant but the amount of spotting of the fruit was very slight. However, a few of the characteristic spots were found upon the fruits. Isolutions were made from both of these sources and the same yellow organism was obtained. The organism isolated from the cankers was grown side by side with these in all of the common culture media, and the fact established that they are identical. Moreover, the cultural characteristics agree in all respects with the original description of Smith for Pseudomonas pruni. I feel no hesitancy, therefore, in assigning this organism as the cause of the cankers herein described. Incidentally it has also been shown that this organism is capable of causing canker of peach trees upon cross inoculations.

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NORTH AMERICAN FROG BLADDER FLUKES

By W. W. Cort*

The bladder fluke of the frog was first reported in Europe by Loschge (1785), and fifteen years later was given the name *Distomum cygnoides* by Zeder (1800). But not until Looss (1894) published his classic work on the distomes of European fish and frogs, did it receive an adequate description.

Leidy (1851: 207) was the first to notice bladder flukes in American frogs, but his description is too brief and superficial to make a precise diagnosis of his forms possible. The first detailed description of these flukes from this continent was Bensley's account (1897) of two varieties of *Distomum cygnoides* from Canada. From material also collected in Canada Stafford (1902) later reported Bensley's two varieties and described also three new species. As far as I can find out, the literature contains no further mention of frog bladder flukes from North America.

The evolution of the nomenclature of this group is very interesting, and gives a typical illustration of the advance during the last decade in the knowledge of the structure of distomes. Braun (1899) was among the first to feel that the old genus *Distomum* was an unnatural group. He recognized the similarity in structure between the bladder flukes found in different cold blooded vertebrates, and suggested that *Distomum folium, Distomum cygnoides, Distomum cymbiforme,* and *Distomum patellare* be grouped together into the new genus *Phyllodistomum* with *Distomum folium* as the type species. Looss (1899) published the same year the first of his papers on the division of the genus *Distomum.* He further split up Braun's group, and for the distomes from the urinary bladder of the frog established the new genus *Gorgodera* (1899: 695). The old form *Distomum cygnoides* was made the type species and Bensley's American varieties were included in it as separate species under the

*Contributions from the Zoological Laboratory of the University of Illinois, under the Direction of Henry B. Ward, No. 17.

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names *Gorgodera amplicava* and *Gorgodera simplex*. In his earlier work Looss (1894) had mentioned that the frog bladder fluke described by Olsson as *Distomum vitellilobum* had only two testes instead of nine as in *Distomum cygnoides*, but he considered it to be a young form of the latter species. The discovery that *Gorgodera simplex* had only two testes, however, caused him to include in his diagnosis of *Gorgodera* forms with both two and nine testes. Stafford (1902) accepted Looss' new genus and named his three new species *Gorgodera translucida*, *Gorgodera opaca*, and *Gorgodera attenuata*. He noted that this genus should be divided into two groups, one containing forms with two testes and the other with nine, but he made no attempt to separate them into distinct genera. In the same year Looss (1902: 851) divided the genus *Gorgodera*, and established for the species with two testes the genus *Gorgoderina*. Later Stafford (1905: 687) accepted Looss' grouping and renamed his species of 1902 accordingly.

Stafford's species are very poorly described and in some of them the most essential points for comparison are omitted entirely. The differences which he noted between *Gorgoderina simplex* and *Gorgoderina opaca* are so slight that I am forced to doubt their specific distinctness. He based his description of *Gorgoderina opaca* on three specimens, which he found with a large number of *Gorgoderina translucida* in toads. After comparing his description of *Gorgoderina opaca* with the two descriptions and a specimen of *Gorgoderina simplex*, the only two points of difference which hold good are the greater width and bluntness of the posterior body region in the former species, and the difference in hosts. The first difference is probably due to a more contracted condition, and since in this group there seems to be no very definite specificity of hosts the second difference loses its value. None of Stafford's type material could be obtained. Considering these facts I feel justified in calling *Gorgoderina opaca* a synonym of *Gorgoderina simplex*.

Gorgoderina translucida differs from all the other species of this genus in the broadness and thinness of its posterior body region. Osborn (1903) notes its similarity to *Phyllodistomum americanum* from the salamander and after comparison of specimens of the two species states that he considers them to be in the same genus. The

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structural differences between the genus *Phyllodistomum* from the urinary bladder of fish and *Gorgoderina* from frogs and toads is not great and depends largely on differences in body shape, the members of the former genus being flat and spatula-shaped and of the latter thicker and more cylindrical. *Gorgoderina translucida* and *Phyllodistomum americanum* in both hosts and shape seem almost to constitute a transition between the two genera. Another observation along this same line is that of Ssinitzin (1905) who, after comparing *Gorgoderina vitellilobum* and *Phyllodistomum folium,* considered their structure to be so similar, that he decided that they belonged to the same genus. Therefore he put *Phyllodistomum folium* which is the type species of its genus into the genus *Gorgoderina.* I feel that at this time I have not sufficient data to pass judgment on the relationship of these two genera.

The European members of these genera are well known and their whole life histories have been thoroughly worked out. The American forms on the other hand are very slightly known, having been reported but few times and very inadequately described. As already noted but three authors have reported frog bladder flukes from North America.

Leidy (1851:207 & 1856:44) reported bladder flukes which he called *Distomum cygnoides* from *Rana pipiens, Rana palustris, Rana halecina, Salamandra maculosa, Salamandra rubra,* and *Salamandra salmonea.*

Bensley (1897) described *Distomum cygnoides* var. A and B, forms which were later called *Gorgodera amplicava* and *Gorgoderina simplex* from *Rana clamitans, Rana virescens,* and *Rana catesbina* from Toronto, Canada.

Stafford (1902) also from Toronto, Canada, described *Gorgoderina translucida,* from *Bufo lentiginosus* and *Rana virescens, Gorgoderina opaca* from *Bufo lentiginosus, Gorgoderina simplex* from *Rana catesbina, Gorgoderina attenuata* from *Rana virescens* and *Rana catesbiana,* and *Gorgodera amplicava* from *Rana catesbiana.*

I have at hand for the present study *Gorgoderina attenuata* from *Rana catesbiana,* Rice Lake, Ontario, from *Rana pipiens,* Urbana, Illinois, from *Rana pipiens,* Bemidji, Minnesota, and from *Rana pipiens,* North Judson, Indiana; further *Gorgodera amplicava*

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and *Gorgoderina simplex* from *Rana catesbiana,* Rice Lake, Ontario; and finally a new species of *Gorgodera* from *Rana virescens,* Urbana, Illinois, and from *Rana pipiens,* Bemidji, Minnesota.

From a study of the above material I am able to supplement Stafford's short description of *Gorgoderina attenuata* and add the description of a new species in the genus *Gorgodera.*

Gorgoderina attenuata Stafford 1902

During the fall of 1910 while examining for parasites a number of leopard frogs (*Rana pipiens*) I found in the urinary bladder of nine hosts thirty-seven specimens of *Gorgodera attenuata* Stafford. The heaviest infection in a single frog was nine. In the following spring Dr. Henry B. Ward kindly turned over to me a number of individuals of the same species collected by A. J. Huntsman from bull-frogs (*Rana catesbiana*) at Rice Lake, Ontario, Canada. These Canadian forms were a little smaller and more attenuated than those from *Rana pipiens.* There can be no doubt in my estimation that these two lots are both *Gorgoderina attenuata.* The size and ratio of the suckers, the shape of the body and size of the egg all correspond. The specimens from the bull-frog are a little less crowded with eggs and are probably a little younger than the other lot. This species is easily recognized on account of the extreme attenuation of the posterior region of the body, and the large size of the acetabulum as compared with the oral sucker (Fig. 7).

On account of the great activity of the worms only the general body relations could be made out in the living material. With the acetabulum firmly attached to the wall of the bladder, the posterior end would often stretch out to two or three times its normal length, become very slender and lash violently from side to side. In no other species of bladder flukes which have been examined alive has this activity been so pronounced. The total length of the living worms was about ten or twelve times their width, and the ventral sucker which was like a large bowl attached at its base, divided the animal into two distinct regions. The anterior region was cylindrical and narrow, comprising about one-third to one-fourth the length of the animal, and the posterior region, which was three-fourths as thick as wide, ended in a rather sharp point.

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Sixteen of these specimens, when preserved in alcohol, varied in length from 3.3 mm. to 7.2 mm., while the Canadian material ranged from 3.5 mm. to 4.8 mm. The width depends somewhat on the state of contraction, varying from about 0.35 mm. to 0.56 mm. Measurements of cross sections of three different worms at the region of the anterior testis gave 0.46 mm. in width by 0.35 mm. in thickness, 0.56 mm. in width by 0.46 mm. in thickness, and 0.54 mm. in width by 0.46 mm. in thickness.

The ratio in size of the suckers (*os, vs,* Fig. 7) in *Gorgoderina attenuata* offers an important point in specific diagnosis, and separates it from all the other American species of this genus. The oral sucker in sixteen specimens ranged from 0.26 mm. to 0.33 mm. in diameter, and the acetabulum from 0.6 mm. to 0.82 mm., always having a width noticibly greater than the width of the body. The ratio of the suckers varied in different individuals from 1:2.1 up to 1:3 with an average ratio of 1:2.5. Stafford notes the ratio in *Gorgoderina translucida* as 1:1.5 to 1:1.75 and in *Gorgoderina simplex* as 1:1.3 up to 1:1.5. As noted by this author in these two species, and observed by me in *Gorgoderina simplex,* the edges of the acetabulum do not extend beyond the sides of the body.

The digestive system offers few points of importance in specific diagnosis. The mouth opens ventrally thru the oral sucker into a narrow esophagus about 0.4 mm long. The intestinal ceca are wide apart and close to the lateral margins in the region of the body occupied by the reproductive organs, but back of the posterior testis they approach each other and terminate almost in contact not far from the posterior extremity of the animal.

As in other trematodes the anatomy of the reproductive system offers the clearest specific differences, and will be considered in some detail. Just back of the acetabulum are the paired vitelline glands (*v,* Fig. 7), which are compact organs, lobed but not divided into follicles, and connected by a transverse duct. The ovary (*o,* Fig. 7), is a small round or oval structure close behind the vitellaria and to one side of the body. In seven out of thirteen speciments the ovary was on the right side, the anterior testis to the left and the posterior testis on the same side as the ovary, and in the other six this order was reversed. This arrangement seems to indi-

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cate a condition of sexual amphitypy in this species. In a specimen 5.2 mm. in length, the ovary measured 0.32 mm. in length by 0.24 mm. in width. It is wider than thick and lies near the ventral surface. In a cross section which measured 0.31 mm. in width by 0.33 mm. in thickness, the ovary had a width of 0.22 mm. and a thickness of 0.20 mm. (Fig. 4). The ratio of thickness to width is greater than in most trematodes, but less in the next species to be described.

The testes are rather large, slightly elongated structures, lying the one slightly behind the other on opposite sides of the body, the anterior being just behind and on the opposite side from the ovary (*t*, Fig. 7). They have a greater thickness than width and lie toward the dorsal surface. In the mount for which the ovary was measured the anterior testis had a length of 0.78 mm. and a width of 0.30 mm.; and the posterior testis was 0.93 mm. in length by 0.32 mm. in width. In a cross section 0.47 mm. in width by 0.44 mm. in thickness, the anterior testis measured 0.20 mm. in width by 0.26 mm. in thickness. From the anterior ends of the testes the vasa efferentia pass forward. They run close along the dorsal body wall and unite in front of the vitellaria to form the vas deferens. Just anterior to the attachment of the acetabulum, the vas deferens enlarges into the seminal vesicle, a large pyriform sac filled with sperms. From the dosal margin of the anterior end of this organ, the ductus ejaculatorius goes directly ventrad to the genital pore, having clustered around the middle of its course the prostate glands, and being of about uniform caliber thruout its length (*p*, Fig. 5).

The connections of the female reproductive system of *Gorgoderina attenuata* are toward the dorsal surface. The oviduct originates from the middle of the dorsal surface of the ovary, and widens almost immediately into the fertilization space. It soon narrows again and gives off Laurer's canal before entering the region surrounded by the unicellular gland cells of the so-called "shell gland" (Fig. 13). Since Goldschmidt (1909) has conclusively shown that this structure has nothing to do with the production of shell material, I shall follow his lead in discarding the name of shell gland, and call it Mehlis' gland after its discoverer. Within Mehlis' gland and the oviduct becomes thicker walled and changes to the ootpye, which receives the short median duct from the yolk glands.

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The beginning of the uterus passes forward, curves over between the yolk glands, and is lost in the mass of coils which fill the posterior body region. The coils and folds of the uterus of *Gorgoderina attenuata* are so complicaed that it is impossible to distinguish any definite arrangement. In fact they seem to fill all the available space in the posterior end and this whole region is so crowded with eggs that all the organs are more or less obscured. In front of the vitellaria the uterus makes several voluminous transverse folds, and then passes forward along the mid line of the body to the genital pore. The last part is modified into a short metraterm (*mt*, Fig. 5), which has slightly thicker walls than the rest of the uterus.

Eggs from living individuals of this species taken from near the genital pore, measured about 0.053 mm. by 0.034 mm., while eggs from the same region of alcoholic specimens were only 0.032 mm. by 0.022 mm. This shows the danger in the study of species having thin shelled eggs of comparing the measurements of eggs from alcoholic material with those from living animals. In the largest eggs fully developed miracidia could be seen turning around within the shell. Such eggs when placed in ordinary tap or distilled water after ten or fifteen minutes began to pop open and liberate the miracidia. In fact when the worm was broken up in water on a slide, and studied under high power, in a short time great numbers of the minute larvae swarmed across the field of vision. They were cylindrical in shape, pointed at one end, and swam with a rapid whirling motion. Gradually they became distorted and went to pieces, none living more than a few minutes. We can judge from the above observation that in a few minutes after the eggs pass from the salinity of the frog's bladder into the surrounding water the change in osmotic pressure liberates the miracidia, which start in their search for a snail host. Whether they can live for more than a few minutes it would take further observations and experiments to decide. It may be of value to note in this connection that for the demonstration of the miracidia stage of trematodes to classes, there is probably no material more easily obtained and better for study than the larvae which are liberated from the eggs of the frog bladder flukes. As in all the forms of this group I have ever seen, the eggs are in an advanced stage of development, I am confident that this experiment would work with any of these species.

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GORGODERA MINIMA NOV. SP.

In the fall of 1910 I found in the bladder of a large specimen of the bull frog (*Rana catesbiana*) fifty very small trematodes (Fig. 1) which differed so greatly from all the known species that I have considered them to belong to a new species of the genus *Gorgodera*. In October of the following year, I obtained some further specimens (Fig. 2) of the same species, which had been collected from the leopard frog (*Rana pipiens*) at Bemidji, Minnesota, by Herman Douthitt. In the bull frog the wall of the bladder was thickly crowded with the minute worms, which were so tightly attached by the acetabulum, that it was necessary to tear the tissue of the bladder to shreds before they would loosen their hold. When killed in corrosive acetic by the shaking method of Looss the worms became somewhat contracted, and showed a tendency to bend backward at the acetabulum forming an angle of almost 90 degrees.

These distomes vary in length from 0.9 mm. to 1.58 mm. The smallest individuals have a considerable number of eggs in the posterior end, while the largest have the uterus crowded thruout its length. In a specimen measuring 1.58 mm. the internal organs were almost entirely obscured, and the posterior end assumed the character of a distended egg sac. The extremely small size of this species is very striking. In the genus *Gorgodera* the smallest previously described form is between 3 mm. and 5 mm. in length, and the others are all over 7 mm. I shall call this new species *Gorgodera minima*.

The ventral sucker divides the worm into two nearly equal parts (*vs*, Figs. 1 & 2), the anterior region being somewhat narrower and shorter than the posterior. Both regions are almost cylindrical, the posterior tapering slightly to a blunt point. In an individual crowded with eggs, a cross section thru the middle of the anterior end measured 0.27 mm. in width by 0.26 mm. in thickness (Fig. 8), one at the region of the ovary 0.37 mm. in width by 0.31 mm. in thickness (Fig. 10), and one thru the posterior testis 0.31 mm. by 0.27 mm. (Fig. 11).

The acetabulum in *Gorgodera minima* is very large as compared with the size of the worm and appears much as in the pro-

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ceeding species. It is circular from ventral view, the average diameter for ten specimens being 0.39 mm. The oral sucker has a diameter of about 0.20 mm., making the ratio of the two a little less than 2:1.

The mouth appears as a slit-like transverse aperture toward the anterior part of the oral sucker (*m*, Fig. 1), opening ventrally and about one-fifth or one-sixth the width of the sucker. The esophagus is short and narrow, about 0.017 mm. in width and 0.12 mm. in length. The intestinal ceca are about 0.06 mm. in width and at the beginning of their course are dorsal, and wide apart to give room for the greatly developed vesicula seminalis. In the narrow portion of the animal just dorsal to the acetabulum the ceca come closer together, and just posterior to this structure they spread very widely to pass to the outside of the reproductive organs, which fill almost the entire width of the animal at this region. They continue backward outside of the reproductive organs almost to the posterior extremity of the body. They may be next to the outside wall or portions of the uterus may run to the outside of them.

The reproductive system of *Gorgodera minima* is very similar to that of *Gorgodera amplicava* and *Gorgodera cygnoides*. The chief differences are in the relative size of the parts and in the distances between them, which to some extent at least are determined by the size and shape of the animal. The testes are nine in number, five on the same side as the ovary and four on the opposite side (Fig. 1). They are in shape rectangular prisms crowded very closely together. All the testes seem to be about the same size and the average measurements for a single testis are 0.05 mm. longitudinally, 0.08 mm. laterally, and 0.24 mm. dorsoventrally (Fig. 11). This peculiar shape is an important distinguishing feature of the species. One might compare the testes to two series of cigar boxes attached by strings thru their centers and arranged four on one side and five on the other, with the strings from each lateral series connecting further forward. The testes themselves are somewhat irregular in outline, slightly lobed, and connected by a series of short tubules. From the middle of the anterior surfaces of the anterior testes on each side run forward the vasa efferentia. These tubules unite in front of the ovary and the yolk glands into the vas deferens, which passes dorsal to the acetabulum into the vesicula seminalis,

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a large pyriform sac following a slightly spiral course and filled with sperms (*s*, Fig. 1). In a worm 0.9 mm. long this organ measured 0.14 mm. in length, and in a cross section of another worm, 0.30 mm. in width and 0.26 mm. in thickness, it measured 0.99 mm. in width by 0.11 mm. in thickness (Fig. 8). These measurements are of course somewhat modified by the state of contraction, but are given to show the relatively large size of the seminal vesicle in this species. From the anterior end of the seminal vesicle the ejaculatory duct curves down, and opens ventrally at the common gential pore. This duct is quite long in *Gorgodera minima* and widens out before opening into the pore into a small chamber lined with rather tall epithelial cells among which are heavily staining club-shaped cells, which appear to be glandular. Around the first part of the ejaculatory duct are grouped the prostate glands (*p*, Fig. 6).

The vitellaria in *Gorgodera minima* are composed of two groups of nine to eleven follicles each, lying one to each side of the animal just back of the acetabulum. They are connected by a transverse vitelline duct which opens into a common vitelline reservoir. On the left side immediately behind these glands, and often overlapping them ventrally is the ovary which is irregular and slightly lobed, and has a thickness almost equal to the thickness of the worm (Fig. 4). In a cross section thru the middle of the ovary, 0.28 mm. wide by 0.26 mm. thick, this organ had a width of 0.12 mm. and a thickness of 0.20 mm. (Fig. 10). It lies toward the ventral surface and is widest toward this side. In a frontal section 1.1 mm. long by 0.28 mm. wide, the ovary measured 0.1 mm. with the length of the animal and 0.15 mm. with its width. None of my specimens showed sexual amphitypy, in all of them the ovary being to the left. The oviduct leaves the dorsal surface of the ovary, widens immediately into the fertilization space, and narrowing again, passes forward still near the dorsal surface to change into the ootype within Mehlis' gland. This is a small group of unicellular gland cells, which lie dorsally between the groups of follicles of the vitelline glands. Within Mehlis' gland the median duct from the vitellaria opens into the ootype. Laurer's canal opens from the oviduct about half way between the fertilization space and the ootype. From its junction with the oviduct, this duct which is very narrow, passes ventrad and then doubles back to open on the dorsal surface back of the ovary (Fig.

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3). As with the testes the longest axes of the vitellaria and ovary are with the thickness of the animal.

From the ootype the uterus goes to the side opposite the ovary and folds down the region outside of the testes to the posterior extremity of the body, where it fill with its coils the region back of the intestinal ceca and testes. From this region it winds forward on the opposite side, filling not only the region between the groups of testes, but also all the available space between the testes and body wall and even between the individual testes. In front of the testes it emerges from this mass of coils, to pass to the ventral side of the ovary, over the acetabulum and forward ventral to the vesicula seminalis to the genital pore (Fig. 4). In such a uterus as the one described above the whole course is distended with eggs. In younger worms where fewer eggs are present there is less complication. In general the course of the uterus is down the side opposite the ovary and up the other side to the genital pore filling all the available space between the organs.

The eggs in *Gorgodera minima* increase in size as they develop in the uterus from the ootype to the gential pore. In preserved specimens the eggs average in size at the ootype about 0.021 mm. by 0.014 mm., in the coils of the posterior end 0.024 mm. by 0.017 mm., and just behind the genital pore, where they contain fully developed embryos, 0.032 mm. by 0.022 mm. Looss (1894:63) notes similar differences in size in the eggs of *Distomum cygnoides*. I have no measurements of eggs from living animals. As noted by Stafford (1902:418) in *Gorgoderina simplex* and observed by me in *Gorgoderina attenuata* eggs of the type found in this group shrink considerably after preservation in alcohol. Therefore in this species also comparisons should not be made between living and preserved eggs.

Gorgodera minima is the second American species of the genus *Gorgodera*, the other species being *Gorgodera amplicava*, described by Bensley (1897). The most striking differences between these two species are in the size and shape of the animals, the ratio in size of the suckers, and in the shape and relations of the reproductive organs. *Gorgodera minima* is a very small worm, 1 to 2 mm. in length, with the anterior and the posterior regions of almost equal size and almost cylindrical, while *Gorgodera amplicava* is

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much longer, 3 to 5 mm., considerably wider, with the posterior body flattened and pointed much like the blade of a two edged knife. The anterior region in this worm is also very small in proportion to the posterior, being about one-third as long and not one-fourth as wide, altho thicker. In *Gorgodera amplicava* the acetabulum is not only twice as large as in *Gorgodera minima,* but is from two and one-half to three times as large as the oral sucker, while in the later species the ratio is less than two to one. The great relative thickness of the testes and ovary in *Gorgodera minima* is another feature which differentiates it from *Gorgodera amplicava.* The seminal vesicle is relatively much larger in the former than in the latter species. The European species of *Gorgodera* are larger than the American, all being over 7 mm. in length. *Gorgodera minima* is by far the smallest representative of the genus *Gorgodera* yet reported.

In order to facilitate comparison there is given here a list of the genera and species of frog bladder flukes, a table of the hosts and localities of the forms reported from North America, and a key for the identification of North American species.

Of frog bladder flukes there have been described two genera and ten species:

GORGODERA	GORGODERINA
Gorgodera Pagenestecheri Ssinitzin	*Gorgoderina simplex* Looss
Gorgodera Loossi Ssinitzin	Syn. *Gorgoderina opaca* Stafford
Gorgodera Varsoviensis Ssinitzin	*Gorgoderina vitellilobum* Olsson
Gorgodera Amplicava Looss	*Gorgoderina translucida* Stafford
Gorgodera minima Cort	*Gorgoderina attenuata* Stafford.

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The following table includes all the reports which could be found of frog bladder flukes from North America.

FROG BLADDER FLUKES REPORTED FROM NORTH AMERICA

Date	Author	Name used	Present name	Hosts	Locality
1851	Leidy.	Distomum cygnoides.	(?)	Rana pipiens, Rana palustris, Rana halecina, Salamandra maculosa, Salamandra rubra, Salamandra salmonea.	(?)
1897	Bensley.	Distomum cygnoides, var. A.	Gorgodera amplicava.	Rana clamitans.	
				Rana virescens.	Toronto, Canada.
		Distomum cygnoides, var. B.	Gorgoderina simplex.	Rana catesbiana.	
1902	Stafford.	Gorgodera translucida.	Gorgoderina translucida.	Bufo lentiginosus. Rana virescens.	Toronto, Canada.
		Gorgodera simplex.	Gorgoderina simplex.	Rana catesbiana	Toronto, Canada.
		Gorgodera opaca.	Gorgoderina simplex.	Bufo lentiginosus.	Toronto, Canada.
		Gorgodera attenuata.	Gorgoderina attenuata.	Rana virescens. Rana catesbiana	Toronto, Canada. Toronto, Canada.
		Gorgodera amplicava.	Gorgodera amplicava.	Rana catesbiana	Toronto, Canada.
1912	Cort.		Gorgoderina simplex.	Rana catesbiana	Rice Lake Ontario, Can.
			Gorgodera amplicava.	Rana catesbiana	Rice Lake Ontario, Can.
			Gorgoderina attenuata.	Rana catesbiana	Rice Lake Ontario, Can.
			Gorgoderina attenuata.	Rana pipiens.	Urbana, Ill.
			Gorgoderina attenuata.	Rana pipiens.	North Judson, Ind.
			Gorgoderina attenuata.	Rana pipiens.	Bemidji, Minn.
			Gorgodera minima.	Rana pipiens.	Bemidji, Minn.
			Gorgodera minima.	Rana catesbiana	Urbana, Ill.

The following key may be of value to American workers for the identification of any specimens of this group which may fall into their hands.

KEY TO NORTH AMERICAN FROG BLADDER FLUKES

1(4) Bladder flukes with nine testes.

Genus *Gorgodera* Looss 1899...2

2(3) Length 3-5 mm.; posterior body region flat and transparent; acetabulum 2.5 to 3 times the size of oral sucker.

Gorgodera amplicava Looss 1899

3(2) Length 1 to 2 mm.; posterior body region opaque and almost cylindrical; acetabulum 1.6-2 times oral sucker.

Gorgodera minima nov. sp.

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4(1) Bladder flukes with two testes.
Genus *Gorgoderina* Looss 1902...5

5(6) Posterior body region broad flat and transparent; thickness about one-third the width.
Gorgoderina translucida Stafford 1902

6(5) Posterior body region opaque and thick; thickness one-half or more than one-half width.....7

7(8) Acetabulum 1.3 to 1.5 times oral sucker.
Gorgoderina simplex Stafford 1902
Syn. *Gorgoderina opaca* Stafford 1902

8(7) Acetabulum more than 2 times oral sucker.
Gorgodera attenuata Stafford 1902

Osborn's *Phyllodistomum americanum* from a urodele should be mentioned in this connection. It is possible that this form may be found in the frog. Frog bladder flukes which do not come under this key may perhaps belong to one or the other of the European species of these genera not yet reported in this country.

I wish to express my gratitude to Professor Henry B. Ward for the use of material from his collection and for his kindly advice and criticism in the preparation of this paper.

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Abbreviations Used in Plates

e, Esophagus
f, Fertilization space
g, Genital pore
i, Intestine
l, Laurers' canal
m, Mouth
mg, Mehlis' gland
mt, Metraterm
os, Oral sucker
o, Ovary
od, Oviduct
p, Prostate glands
s, Seminal vesicle
t, Testes
u, Uterus
v, Vitelline gland
vd, Vas deferens
ve, Vas efferens
vs, Ventral sucker.

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Explanation of Plates

All drawings were made with a camera lucida.

Plate XV

Fig. 1. *Gorgodera minima* from Urbana, Illinois, seen from ventral surface. Young specimen with but few eggs in the uterus. ×108.

Fig. 2. *Gorgodera minima* from Bemidji, Minnesota, seen from dorsal surface. About the same age and size as figure 1 but slightly less magnified. ×88.

Fig. 3. Reconstruction from frontal sections of the region just back of the acetabulum in *Gorgodera minima,* showing the organs and their connections in the female reproductive system, as seen from dorsal surface. ×180.

Fig. 4. Cross section of body at level of ovary in *Gorgoderina attenuata.* ×180.

Fig. 5. Reconstruction from sagittal sections of *Gorgoderina attenuata,* showing the genital pore and the ends of the ducts of the reproductive systems. ×300.

Fig. 6. Reconstruction from sagittal sections of *Gorgodera minima,* showing the genital pore and the ends of the ducts of the reproductive systems. ×300.

Fig. 7. *Gorgoderina attenuata* seen from ventral surface. ×36.

Plate XVI

Fig. 8-12. A series of cross sections from a specimen of *Gorgodera minima,* showing the structure of important organs at different levels. ×180.

Fig. 8. Section thru the seminal vesicle at about the level of the guide line to *s* in figure 1.

Fig. 9. Section thru the acetabulum at about the level of the guide line to *vs* in figure 1.

Fig. 10. Section thru the ovary at about the level of the guide line to *o* in figure 1.

Fig. 11. Section thru the testicular region at about the level of the middle guide line from *t* in figure 1.

Fig. 12. Section thru the post-testicular region at about the level of the guide line to *u* in figure 1.

Fig. 13. Reconstruction from frontal sections of the region just back of the acetabulum in *Gorgoderina attenuata,* showing the organs and their connections in the female reproductive system as seen from the dorsal surface. ×180.

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NOTES ON THE ANATOMY OF THE TREMATODE, MICROPHALLUS OPACUS.*

SEWALL WRIGHT

This investigation has been carried on with material furnished by Dr. H. B. Ward from type specimens of *Microphallus opacus* collected in 1893 from *Amia calva* in Lake St. Clair. I was unable to use whole mounts to any great extent. Most of the work was done with transverse, frontal and sagittal sections, 5-20μ thick and stained on the slide with Ehrlich's haematoxylin. This species was first described by Ward in 1894 as *Distoma opacum*. Its present genus, *Microphallus,* of which it is the only member was founded by Ward in 1901. A description of the general appearance and of the suckers may be found in Ward (1894) and need not be repeated.

The body wall is of the usual type among trematodes. There is a noncellular cuticula, several layers of muscle fibres and a region of closely packed cells merging with the looser parenchyma. The cuticula presents a finely dotted appearance, the nature of which was not determined. Adjacent to the cuticula is a layer of very fine muscle fibres, a little over 1μ apart. Next is a layer of coarse longitudinal fibres and two layers of coarse oblique fibres making angles of 60° with each other and the longitudinal, the three thus forming a pattern of equilateral triangles. The fibres in these layers are at varying distances apart depending upon the part of the body examined. They are most abundant in the anterior ventral region. The cuticula continues into the digestive tract lining the prepharynx and esophagus. Coarse longitudinal fibres, some two dozen in number, lie below the cuticula in these regions. The pharynx is composed mainly of radial muscle fibres but has a layer of circular fibres on the inside and anteriorly on the outside.

The excretory system consists of sixteen large flame cells, a system of canals, a large bilobed vesicle, and a short ciliated canal

*Contributions from the Zoological Laboratory of the University of Illinois, under the Direction of Henry B. Ward, No. 18.

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to the exterior (Fig. 2). The details were obtained by reconstructing the system in four series of transverse sections. The reconstructions were made by measurements with the ocular micrometer and plotted on a previously reconstructed lateral or dorsal view of the animal. These four series checked with each other. The number and position of the flame cells was checked in several other series. The excretory pore as a rule is placed dorsally and slightly in front of the extreme end. It is at the end of a short, thickly ciliated canal, the outlet of a vesicle which extends forward for one-third to two-fifths of the length of the body. Almost from the first the vesicle shows median longitudinal constrictions on the dorsal and ventral surfaces, and at one-third to one-half its length it divides completely into right and left lobes. These are more or less cylindrical, tapering somewhat at the anterior end. The whole vesicle lies fairly close to the dorsal surface. The lining of the vesicle and its outlet are crowded with nuclei but muscle fibres were not detected.

The system of canals and flame cells is bilaterally symmetrical, eight flame cells on each side of the body. There is also a certain biradial symmetry. As mentioned above, the vesicle lies along the dorsal surface of the body. A canal drops to the ventral surface from the anterior end of each lobe and divides into a posterior and an anterior branch. Four flame cells supply the posterior and four the anterior and with corresponding canals. In fact, all of the flame cells are similarly placed with respect to canals; all have just three forks between them and the excretory vesicle. In each of the pairs of flame cells which are immediately connected by a fork, one is decidedly dorsal, the other ventral.

The details of the system can best be described by considering one side of the body only (Figs. 1 and 2). The first ventral flame cell is at the side of the anterior sucker, often closely against it. The first dorsal is above the esophagus, a little off the median line. Canals run from them and unite near the side of the body. The united canal runs back longitudinally. The second ventral flame cell is lateral to the intestinal branches or seminal vesicle and not far from the ventral surface. The second dorsal is above these organs and near the median line. In some specimens the second ventral or second dorsal flame cell is close against the seminal vesicle or ovary,

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but this seems to be an accidental relation. The canals of this pair unite a little above the longitudinal canal from the first pair of flame cells and are joined with the latter by a very short canal. In one case this short canal was shortened to disappearance on one side. Beyond the junction the canal continues longitudinally to the region along side of the ventral sucker where it is joined by the corresponding canal supplied by the third and fourth pairs of flame cells. The fourth ventral flame cell is near the posterior end of the animal, pressed back by the last fold of the uterus. The fourth dorsal is close against the posterior side of the testis on that side of the body. Canals from these two run toward each other and toward the side of the body all the time confined in the narrow space between uterus and body wall. They are usually pressed flat and difficult to follow. The united canal runs forward and downward still outside the uterine folds. The third ventral flame cell is near the side of the ventral sucker. The third dorsal is close against the anterior face of the testis. I found one exception in which it was considerably anterior to the testis. The canals of this pair run outside the folds of the uterus and join near the ventral surface. The resulting canal runs posteriad to a union with the canal supplied by the fourth pair. The canal thus formed runs in toward the ventral sucker to join the canal supplied by the first four flame cells on that side of the body as mentioned above. The large canal following this union runs perpendicularly upward between the folds of the uterus, the only one to do so, to the anterior end of the lobe of the excretory vesicle on its side.

These flame cells are very favorable for study. They are very large and of typical form, each cell having a conspicuous nucleus, cytoplasmic processses in all directions, and at one side a conical bunch of cilia some 15μ long which projects into the blind end of a canal.

The great simplicity of the excretory system may be merely correlated with the small size of the animal and due to degeneration, but it seems not unlikely that it has more significance. In the fact that the main trunks divide in the middle of the body into anterior and posterior branches, it is a good representative of Looss' typical form for distomes of which he (1894) considers such forms as that in which the main trunks go to the anterior end of the body and re-

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turn on themselves, or in which the system is a complex network, to be later modifications.

In the nervous system, the large nerves show fairly well on slides stained with haematoxylin as gray bundles of fibres in a blue background. The smaller nerves, I frequently had trouble in following from section to section. Only the large nerves could be followed in transverse sections. Various tangential sections gave the best results.

The central part of the nervous system is a large mass forming an arch over the prepharynx just in front of the pharynx (Fig. 3). Radiating from each end are nerves connecting with the eight longitudinal trunks an dnerves supplying the oral sucker. Six nerves are given off at each end, four in a more or less horizontal plane (Fig. 4), one upwards and one downwards. The largest one runs posteriad from the central mass and lateriad at an angle of about 30°. Near the end of the first third of the body it drops down to the ventral surface and continues back along this surface curving inward somewhat in the region of the ventral sucker. This is the main trunk. The next nerve in order in the horizontal plane is a very fine one, at right angles to the long axis of the body and connecting with the lateral trunk. Next comes a large bundle going forward and out some 45° and dividing into a short branch running to the sides of the oral sucker and the large lateral trunk which runs far back along the lateral margin of the body. A large but short branch runs directly forward over the dorsal surface of the oral sucker. The ventral bundle runs outwards and forward somewhat and is connected at the ventral surface with the corresponding nerve on the other side by a commissure. Two small nerves run forward from points near the connection and the fairly large ventral longitudinal trunk runs backward one-fourth to one-third the length of the animal. It stops just where the main trunk reaches the ventral surface. The dorsal bundle from the central mass divides at the dorsal surface, the forward branch running to the anterior end of the body, curving down with the curve of the body and ending just above the oral sucker while the backward branch is the dorsal longitudinal trunk and runs back parallel to the long axis of the animal. A short distance back of the central mass the main trunk sends out large nerges to the ventral, lateral, and dorsal trunks (Fig.

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5). The dorsal and lateral trunks and the nerves on the ventral surface, the ventral and main trunks, are connected by commissures. In my preparations I could not determine the number satisfactorily and in the case of those connecting with the lateral trunks none were found which could certainly be demonstrated as complete commissures. The main trunk sends a couple of branches from each side to the ventral sucker. These seem to run directly into the circular muscles surrounding the base of the sucker. The system in the posterior part of the body could not be determined at all.

This arrangement of the nervous system agrees in most respects with that which I have found described for other distomes. I have not, however, found reference to the ventral longitudinal trunk. The main trunk is the one usually called ventral. As the ventral trunk is immediately below the main trunk, close to it, and smaller, it would probably be difficult to distinguish in whole mounts.

Only a few additions need be made to the description of the reproductive system by Ward (1894 and 1901). There is a curious interweaving of the vasa deferentia, the yolk ducts and the uterus (Figs. 8 and 9). The vasa deferentia run forward and downward from the testes and unite in the middle region of the body. The yolk ducts run forward and upward from the yolk glands and unite above the union of the vasa deferentia. Instead however of passing each other symmetrically, the right yolk duct passes in front of below the right vas deferens while the left yolk duct passes over and behind the left vas deferens. The uterus passes in front of the yolk duct but behind the vasa deferentia. The yolk ducts are distorted from bilateral symmetry somewhat, the vasa deferentia more. This was the relation in all series examined including one described later in which there were two ovaries so that the reproductive organs were unusually symmetrical.

Ward (1894) after stating that as the animals become mature the yolk glands increase in size, continues thus: "In older specimens, I am inclined to think that they are again reduced in size but evidence on this point is incomplete." My slides are not of the right stages to give evidence on an early increase in size, but they clearly show a later reduction. The changes in the size of all the reproductive organs are very interesting. In young specimens the yolk ducts end in large masses occupying most of the sides of the posterior half

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of the body. Each gland is composed of a number of large spherical lobes, some fused side by side and some connected by small ducts in an irregular way. In these specimens the uterus is a narrow tube winding around in the parenchyma between the two yolk glands; the ovary and testes are large and round often over one-half the thickness of a cross section, while the seminal vesicle may be rather small, often smaller than the ovary (Fig. 6). On the other hand, in older specimens the lobes of the yolk glands lose their spherical appearance and become irregular masses compressed into the mould of the uterine folds which here fill the hind body so completely that almost no parenchyma can be seen (Fig. 7). In some cases nothing can be found of the yolk glands but the stumps of their ducts and perhaps a few scattered yolk cells. Here the testes are smaller and compressed into an irregular shape, and the ovary is smaller, while the seminal vesicle becomes larger than the ovary, sometimes swollen to reach almost from the dorsal to the ventral surface. Thus the organs which produce the components of the egg—ova, sperm, and shell, reach their maximum early. The organs which store the sperm and eggs, reach their maximum later at the expense of the former set. The changes in the yolk glands and uterus are most striking.

At first sight the uterus seems to fill the hind body with a series of irregular, chance folds. These folds cannot be followed in whole mounts owing to concealment by the yolk glands or to their own complexity. Examination of sections shows, however, that there is a simple and fairly constant plan beneath the secondary complexities. I followed the convolutions in nine series. Seven followed the plan below perfectly, the two others differed slightly. The method of study was the reconstruction of serial sections, transverse in eight cases, frontal in the other. The general plan (Figs. 10 and 11) is this: The uterus drops down from the shell gland and enlarges in the center of a cross section in the middle region of the body, proceeds posteriad, enlarging all the time, finally loops forward on the right side, dorsal to the yolk glands, and reaches its starting point. Then it doubles back on itself, retracing its course but ventral to the yolk glands and again reaches the starting point. Then it forms the same folds on the left side but in reverse order and the final portion, become small again, goes forward side by side with

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the first portion and where the latter rises toward the shell gland, the former drops to leave the body at the genital pore. The dorsal circuit on both sides is typically quadrilateral in shape tho there are usually additional minor twists in it. The lateral and anterior sides are the most enlarged portions of the uterus. Sometimes they have a diameter one-fourth that of the body. The ventral circuit is typically triangular, in fact almost invariably has only two bends.

One very remarkable specimen was examined (Fig. 9). Aside from minor peculiarities it was distinguished by having two ovaries. This specimen was the shortest in proportion to its other dimensions of any examined. The dimensions were 1.0x0.7x0.55 mm., length, breadth and thickness. The anterior sucker and digestive tract were normal except that the branches of the intestine were unusually short and diverged at right angles to the esophagus, being closely pressed against the seminal vesicle. The ventral sucker was extremely far back. The opening was at the beginning of the last third of the body. Its breadth was about normal but it was unusually low and very long, far from the normal spherical shape. Its deep cavity was turned posteriad. The seminal vesicle was centrally placed and globular. The ductus ejaculatorius, instead of dropping straight downward, went almost directly posteriad and with the metraterm left the body at an extremely oblique angle. The opening was, however, left of the ventral sucker as is normal. Transverse sections normally split the ductus; here they showed a nearly circular cross section. The two ovaries were exactly paired with each other, right and left. Both were dorsal to the seminal vesicle. Both were ellipsoidal and closely followed by a normal testis. The left ovary, the abnormal one, was considerably the larger. It had no oviduct. The outlet of the right was normal tho somewhat displaced in parts. There was more symmetry in the position of Laurer's canal, the first part of the uterus and the yolk ducts than usual. The relations of the yolk ducts and vasa deferentia were however asymmetrical as mentioned before.

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Summary

The principal points discussed are:

(1) The nature of the integument.

(2) The excretory system, particularly its biradial symmetry and the similar relations of all the sixteen flame cells in the system.

(3) The nervous system, particularly the presence of eight longitudinal nerves.

(4) The asymmetrical relation of the yolk ducts and vasa deferentia.

(5) The alternation in maximum development of yolk glands, ovary and testes on one hand with seminal vesicle and uterus on the other.

(6) The arrangement of the folds of the uterus.

(7) A specimen with two ovaries.

In conclusion I wish to express my gratitude to Professor Henry B. Ward for the material and for the aid and encouragement he has given me in this work.

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Explanation of Plates

Abbreviations

CNM Central nerve mass
DE Ductus ejaculatorius
DLN Dorsal longitudinal nerve
EC Excretory canal
EV Excretory vesicle
FC Flame cell
Int Intestinal branch
LC Laurer's canal
LLN Lateral longitudinal nerve
M Metraterm
MLN Main longitudinal nerve
Oes Esophagus
Os Oral sucker
Od Oviduct
Ov Ovary
P Copulatory papilla
Ph Pharynx
Pre Prepharynx
SG So-called Shell gland
SV Seminal vesicle
T Testis
Ut Uterus
VS Ventral sucker
YD So-called Yolk duct
YG So-called Yolk gland
1D First dorsal flame cell
1V First ventral flame cell
2D etc. Second dorsal flame cell, etc.

Plate XVII

Fig. 1. Excretory system of left side, in lateral aspect, reconstructed by measurements from transverse sections. Somewhat foreshortened. ×60.

Fig. 2. Excretory system. Dorsal view. Reconstructed from same series as Fig. 1. ×60.

Fig. 3. Nervous system. Dorsal view. Diagramatic. ×60.

Fig. 4. Frontal section, showing the nerves leading from the central nerve mass at one side. ×75.

Fig. 5. Transverse section showing the eight longitudinal nerve trunks and two commissures. ×75.

Plate XVIII

Fig. 6. Transverse section thru posterior part of body, showing well developed yolk glands and small uterus. ×45.

Fig. 7. Transverse section similar to that of Fig. 6 but in another series, showing remnants of yolk glands and enlarge uterus. ×45.

Fig. 8. Reconstruction from several transverse sections, showing typical arrangement of reproductive organs (except middle of uterus) from posterior end. ×75.

Fig. 9. Similar reconstruction to Fig. 8. Made from the specimen with two ovaries. ×75.

Fig. 10. Ventral view of the folds of the uterus, reconstructed by measurements from transverse sections. ×60.

Fig. 11. Similar view to Fig. 10. Showing a younger stage. ×60.

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RECENT DEVELOPMENTS IN DRAWING BY THE AID OF PROJECTION APPARATUS, USED ON THE HOUSE LIGHTING SYSTEM.

By Simon H. Gage

In the very first accounts that have come down to us of images in darkened rooms (1558-1568), it is insisted on with great enthusiasm that here is a means to aid in drawing the complex images of natural scenery. For example, Daniello Barbero, who first specifically mentions the use of a lens to give a more perfect screen image, says in his work on perspective, Venice, 1568: "Seeing therefore, on the paper screen the outline of things, you can draw with a pencil all the perspective and shading and coloring according to nature, holding the paper tightly till you have finished the drawing."

Following down the stream of history it is found that every great expounder of projection apparatus brings out with emphasis the help which it promises for lessening the drudgery of getting accurate drawings.

The one thing necessary for bringing about the universal employment of projection apparatus for drawing was the general distribution of a source of light of proper intensity to give images of sufficient brilliancy so that the details could be seen clearly enough to be traced with accuracy. The light must furthermore be under control at all hours of the day and night, and furnish the light from a very small source. The electric light fulfills all the requirements, when used from an arc lamp.

The real advance for drawing was made when it was seen that an arc lamp could be made small enough, or rather that the carbons used in an arc lamp could be made small enough, so that the current used in the ordinary house lighting system could be employed to run the arc lamp.

For this most useful addition to the working machinery of the investigator and the student, we are most indebted to Dr. L. Edinger,

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the eminent director of the Neurologic Institute at Frankfort on the Main. In 1907, only five years ago, he replaced his drawing and photographing outfit using oil or gas light, by one using a small arc lamp. This small arc lamp was worked out and perfected by the optical works of Leitz at Wetzlar.

This method of drawing has been so far perfected and cheapened that it is now available for private workers as well as for institutions; for students as well as for directors of laboratories.

It seemed to the writer that perhaps he could do no better service at this time than to call attention to the method, and point out from his experience with all the forms some of the necessary rules to follow to get the best results most easily and safely.

In the first place one must possess an arc lamp in which the carbons are held at right angles to each other; and, in passing, it is gratifying to remember that the now so widely used right angled arc lamp for projection, was devised in 1894 by Mr. Albert T. Thompson of Boston. Without a lamp for holding the carbons in this position so that the one giving the light can remain constantly in the optic axis, the small drawing outfits would be practically impossible.

The carbons must be small, from the small current used, viz.: 3 to 6 amperes; and they should be soft cored. A small arc lamp is a convenience, but any arc lamp designed for the carbons at right angles can be used by employing bushings or adapters to hold the small carbons.

Either direct or alternating electric current can be used. One must know which current is on his house lighting system, and also the voltage. Both these facts can be learned by inquiry at the office of the electric lighting company furnishing the electricity.

Installing an Alternating Current Arc Lamp.

As alternating current systems are more common than direct current ones, an outfit on such a system will be first considered.

In the first place, it cannot be stated with too much emphasis that: *"One must never try to use an arc lamp on the house lighting system without a rheostat.* Hence in purchasing the outfit it is necessary to get a rheostat adapted for the voltage (usually 110 or 220) and which will not allow more than 5 to 6 amperes of current to flow

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through the lamp. If more current were allowed to flow the fuses of the line would be burned out.

Assuming that the worker has the proper rheostat and lamp, how shall it be connected with the lighting system?

Wiring for the small arc lamp:—This is shown in fig. 1, which is especially prepared to show how to install this drawing outfit. It is also shown in fig. 6, 13, and 14. One can use the good, heavy flexible twisted wire, but it is better to use the asbestos covered cable employed for flat irons and other heating devices. A cord from one to three meters in length (3 to 10 ft.) will usually suffice.

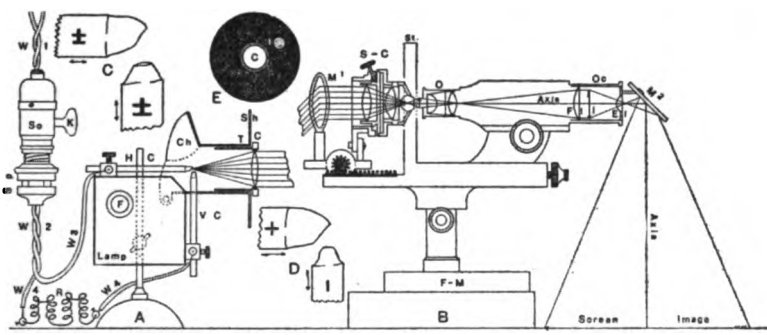

Fig 1

Fig. 1. Diagram of the Microscope for drawing, the Arc Lamp with small right angled carbons, the Wiring, the Rheostat and the connections with the house lighting system.

A. The small arc lamp with the condenser (C) giving parallel rays, the vertical (V-C) and the horizontal (H-C) carbons; F the feeding mechanism, and the wires (W3, direct from the line, W4 through the rheostat). The rheostat (R) is in one wire. The separable plug (Sp) is connected below with the cable (W2) and above with the lamp socket (So) with its key switch, (K). Still above is the incandescent lamp cable (W1) connecting the lamp socket with the house current.

B. The Microscope in section showing the beam of parallel rays from the lamp condenser entering the substage condenser (S-C) directly (as in fig. 14) or reflected in by the mirror (M^1) as in fig. 2, 3, 12, 15); St. Stage of the microscope; O objective, Fl, I, El, the field lens, the real image and the eye lens of the ocular (Oc); M^2 the prism or 45 degree mirror for reflecting the image forming rays down on the drawing paper.

C. Cored carbons of equal size for alternating current.

D. Carbons of the correct relative size for direct current.

E. Face view of the disc on the end of the lamp condenser tube showing the condenser (C) and the spot of light (I) reflected back from the substage condenser.

(1) One end of the cord is connected with the cap of a separable attachment plug (figs. 1, 6). This connection must be carefully and thoroughly made so that there will be no short circuits.

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(2) One of the wires of the cable is cut some distance from the other end, and one of the cut ends is attached to one binding post, and the other to the other binding post of the rheostat (figs. 1, 2, 3). This will put the rheostat in series, as it is called. No current can then flow through the lamp or indeed along the wires without passing through the rheostat.

(3) The wires at the end of the cable are now connected with the binding posts of the arc lamp—one wire for each carbon.

All binding screws for connecting the wires with the separable plug, the rheostat, or the arc lamp should be set tight so that there will be good metallic connection and so that, in using the apparatus, the wires will not separate from their connections.

Connection with any lamp socket of the house lighting system can now be made by means of the separable attachment plug (figs. 1, 6).

The arc lamp must be supplied with soft cored carbons not over 8 mm (5-16 in.) in diameter. If only from three to four amperes of current is used, then the carbons should not be over 6 mm. (1-4 in.) in diameter. One must select carbons of a size that the whole end will be heated by the current used or the light will not remain constantly in one axis, and it will be necessary to change the mirror of the lamp to get the light in the optic axis every time the crater wanders on the carbon tip. If the whole end of the carbon is white hot, as will occur if the carbon is small enough, then the light will be steady.

The ends of the two carbons must be in the correct relative position as shown in fig. 1 or the best light will not be given, due to the shading of one carbon by the other.

Installing a Direct Current Arc Lamp

As a direct current arc lamp gives more than twice as much light for the same amperage as the alternating current, it would always be used if available.

The same lamp serves for both currents. The only difference is that for the direct current the upper carbon must be larger as the positive carbon burns out faster than the negative carbon. This is a good proportion: Upper or positive carbon 8 mm. in

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diameter; Lower or negative carbon 6 mm. in diameter. Then they will shorten about equally.

With the alternating current each carbon is positive half the time; with the direct current one carbon is positive all the time and one negative all the time.

In installing the lamp one proceeds precisely as for the alternating current, that is, a separable plug is connected with one end of the cable; a rheostat is inserted along one of the wires, and the other end of the cable has one wire to each binding post of the arc lamp (fig. 1). The only complication is that the positive wire must be connected with the binding post of the upper carbon, and the negative wire to the binding post of the lower carbon.

Usually one does not know which wire is positive and which is negative, and it is necessary to find out by experiment as follows: Connect up the lamp as for the alternating current without regard to positive and negative. Put in some equal sized carbons and turn on the current. Let it run for a minute or two and then separate the carbons till the lamp goes out, then look at the carbons and watch them while they cool. The positive one will be brightest in the beginning, and stay red the longer. If the upper one is brightest it shows that the lamp is connected up correctly. If the lower one is brightest the polarity is turned around. To correct this, pull out the cap of the separable plug, turn it half way around and insert it again. This should reverse the polarity and cause the current to run through the lamp in the right direction. Light the lamp again and make sure that the upper carbon is the brightest and remains glowing the longest. Finally when the upper carbon is positive some kind of a mark should be made on the lamp socket, the plug and its cap so that all can be connected in exactly the same way again, or one would have the trouble of correcting for polarity every time the connections were made.

For turning on the lamp and putting it out, proceed exactly as for the alternating current lamp.

Carbons for the Direct Current Lamp.—Use 8 mm. carbons for the upper or positive one and 6 mm. carbons for the negative or lower one; 7 upper, 5 lower answer also.

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One must look at the carbons occasionally and be sure that they are in the correct relative position to give unobstructed passage to the light toward the condenser (fig. 1 C).

Feeding the Carbons Together.—One must feed the carbons together every two or three minutes for the best effect. With the alternating current the arc might burn for 10 minutes, but the light is not so good as when the carbons are fed often.

Condenser for the Small Arc Lamp.—To collect the light given off by the arc lamp there must be some form of a condenser in connection with it. This can be a large condenser such as is used with magic lanterns (figs. 5, 6, 7, 8, 11, 13) or for the simplest apparatus it is a small condenser in a tube extending out in line with the upper carbon of the arc lamp (figs. 1-3, 12, 14-15). In all the lamps now used for drawing the special condenser is in a telescoping tube so that it can be put at its principal focal distance from the carbon tips, when it will give a beam of nearly parallel light, or the tube can be pulled out more or less, thus giving a converging cone of light.

For a microscope, any compound miscroscope can be used which can be inclined to the horizontal.

For reflecting the image forming rays down upon the drawing paper, a mirror or prism must be put at the end of the tube of the microscope whether an ocular is used or not (fig.1,-15).

The only difficulty one is liable to have with the microscope is that the fine adjustment may not work well when the microscope is made horizontal.

Suppose now that one has a complete outfit, how shall it be put in actual use?

Starting the Arc Lamp

(1) The carbons of the arc lamp should be separated so that they do not touch.

(2) The separable plug is screwed into any lamp socket near the point where the drawing is to be done.

(3) The key switch of the lamp socket is turned on.

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(4) The cap of the separable plug connected with the wiring of the arc lamp is pushed in place.

(5) The carbons of the arc lamp are brought in contact by using the feeding screws of the lamp. If there is current there will be a flash of light. The carbons must be at once slightly separated and the arc will be fully established.

Stopping the Arc Lamp

For putting out the light there are three safe methods:

(1) The carbons are separated by turning the feeding screws of the arc lamp.

(2) If there is a special knife switch as shown in fig. 6, s., that can be opened.

(3) The cap of the separable plug can be pulled off.

Of course one can turn off the current by the use of the key switch in the socket used for turning on and off the incandescent light, but the sockets are not constructed for so much current as is used with the arc lamp, and there is danger of a short circuit and a burning out of the socket or a blowing out of the nearest fuse on the line. It is better, therefore, to shut off the current by either of the three safe methods. If one must turn off the current by the key switch of the lamp socket, it should be snapped over as quickly as possible.

Getting the Light Through the Microscope

There are two different arrangements of the lamp and the microscope (figs. 1-3, 12, 15 and figs. 5-9, 12-14).

(1) All the parts are put in one continuous line, then the source of light, the principal axis of the lamp condenser and of the substage condenser, the objective and the ocular, when one is used, form one continuous axis. This is theoretically the best possible arrangement and is entirely practicable when one has an optical bench on which to arrange the parts as in figs. 5-11, 13. Where there is no optical bench, there is much difficulty in lining up the microscope and the lamp.

(2) The microscope and the lamp with its condenser are placed on the same level, but at approximately right angles to each

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other, and the microscope mirror is used to direct the light through the microscope as in ordinary microscopic observation. Where there is no optical bench as in figs. 1-3, 12, 14-15, it is much easier to get the light through the microscope with this arrangement than with the lamp and microscope in one axis.

For getting the light through the microscope when all parts are in line the microscope mirror is removed or turned aside and then one must adjust the lamp with its condenser until the light goes through the microscope. If there is no optical bench, this is easier said than done, especially with high powers.

With the lamp and microscope at right angles the light is got through the microscope in this simple mechanical fashion:

(A) A disc of card-board, asbestos or tin 15 cm. (6 in.) in diameter is blackened with some dull black paint like "dead-black Japalac;" a hole of the right size is made in the middle and it is put over the telescoping condenser tube as shown in figs. 1-3, 15. This shield helps to cut out stray light, but its main purpose is to act as a screen to aid in getting the light through the microscope.

(B) The plane mirror is set at about 45 degrees facing the lamp. When the light strikes the mirror it is reflected up to the microscope. The lower face of the substage condenser, or if no condenser is used, the slide bearing the specimen, reflects some of this light back on its path to the mirror, and the mirror reflects it back toward the lamp. This light will form a spot on the disc by the lamp condenser (fig. 4). If now one turns the mirror slightly so that the spot of light goes into the lamp condenser then the light will pass through the microscope, and if the reflector beyond the ocular (fig. 1 m^2) is present the image will appear on the drawing surface below, when the microscope is in focus. By a slight movement of the mirror the field will become evenly lighted.

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Use of the Substage Condenser in Drawing

For objectives of 16 mm. (2-3 in.) and higher the substage condenser can be used. It will insure the possibility of bringing into service the entire aperture of the objective. The diaphragm of the substage condenser should be wide open to start with. Sometimes it improves the reflected image to close it somewhat; but as a

Fig. 4

Fig. 4. Black disc at the end of the lamp-condenser tube to cut off stray light and to receive the spot of light reflected back from the substage condenser.

C. The lamp condenser; I, the spot of light reflected back from the substage condenser.

rule it will be found that for drawing, the diaphragm is considerably wider open than for ordinary direct observation.

Mirror to Use.—If a mirror is used to direct the light as in fig. 1-3, then for the 16 mm. one should use the concave mirror and for objectives of 8 mm. and higher the plane mirror should be used.

For objectives lower than 16 mm. the substage should be removed or turned aside and the concave mirror used; or if the parts are all in line (fig. 5-14), the lamp condenser should be in posi-

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tion to give a converging cone of light, and the lamp brought near enough the microscope to fully light the object.

In using the substage condenser for drawing with projection it is necessary to be more precise than for ordinary observation. One should be careful in the first place to have the lamp-condenser so that it gives a practically parallel beam of light as the usual substage condenser is constructed for parallel beams. In the second place the entire field should be lighted. For this one must vary the position of the substage condenser for different objectives. Its position for high powers must be changed depending on the thickness of the slide used also.

A slight change in the position of the substage condenser often acts like magic on the projected image.

Mirror or Prism for Reflecting the Image Forming Rays Downward to the Drawing Surface

If a prism is used it should be large enough to include the entire field, and it must be accurately set to reflect the axial beam so that it strikes the drawing surface at right angles. If a mirror is used, it must be silvered on the face or be of thin glass, otherwise there will be a troublesome double reflection. The mirror likewise should have a stop at the proper angle. For the horizontal microscope the mirror or prism reflects the rays downward at right angles. All that one has to look out for is to have the mirror or prism at 45 degrees and directly above the ocular. If it is at all sidewise there will be a lateral distortion of the image. This is easily seen by turning it considerably, when the projected field will be oval and not circular as it is when the mirror or prism is directly above the ocular.

Drawing in a Dark Room or in the Evening

For drawing in the evening or in a dark room all one needs is any one of the outfits shown and a screen or shield to prevent stray light from the arc lamp from falling on the drawing surface or getting into the face of the draughtsman. A vertical shield of black card-board is good (fig. 2), or a metal enclosure (fig. 14) or the cloth tent (figs. 12, 15).

For drawing in a light room there must be some kind of an enclosure to cut off the excess stray light. There are usually

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plenty of rooms or shady corners where only a moderate amount of shading is necessary, then any of the devices shown in figs. 3, 12-15 will answer. But one must not forget that a screen image which looks brilliant in a dark room will look gray and washed out in a light place.

Objectives and Oculars to Use

So effective is the arc lamp on the house circuit that one can use objectives from the lowest to the water or oil immersions.

The lower oculars give more brilliant images than the higher ones just as for ordinary microscopic observation, but one can use even with the oil immersion, occulars as high as the x8 or x12.

Magnification of the Drawing

This is easily obtained by the use of a stage micrometer. The image of the spaces on the micrometer will, of course, be magnified just the same amount as the specimen drawn, and knowing the actual size of the spaces one can get the size of the image and divide the size of the image by the size of the object and the quotient will be the magnification. For example if the micrometer is in 100ths mm. and the image of one space measures 2.5 mm. then the magnification must have been 250 times linear.

For varying the magnification to get any desired size one has several resources:

(1) Use a higher or lower objective.

(2) Use a higher or lower ocular.

(3) For slight variations in magnification the easiest method is to put the drawing surface farther from or nearer the microscope. This can be accomplished by raising the microscope higher up from the table by the use of aditional blocks or the elevating devices provided (figs. 11, 15) or by the use of an adjustable drawing shelf (figs. 5-9, 13); or finally by the use of a separate drawing table and mirror which can be moved nearer to or farther from the microscope (fig. 8).

For Drawing Large Objects

The small outfits shown in figs. 1-3, 12, 14, 15, do not enable one to draw objects much over 5 mm. in diameter when an ocular is employed. If no ocular is used then objects 10 mm. in diame-

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ter can be drawn. For larger objects, indeed extending up to lantern slide size, one must be supplied with a condenser such as is used for lantern slide projection. The special tube and condenser of the small arc lamp is removed and the lamp put into a lamp-house. Then by the use of a suitable stage or holder for the objects and a suitable objective one can draw objects from the size of lantern slides down, and at a magnification from xi upward.

This is one of the best possible ways of getting lecture room diagrams. For that, one naturally uses a vertical drawing surface, and gets the size by the greater or less distance (see also figs. 11, 13).

For large microscopic objects no ocular is used, and in most cases no substage condenser. The converging cone of light from the large lamp condenser answers perfectly for the illumination. A person who has not tried it will be astonished at the results which can be obtained by means of the arc lamp on the house circuit for lantern slide projection as well as for making drawings.

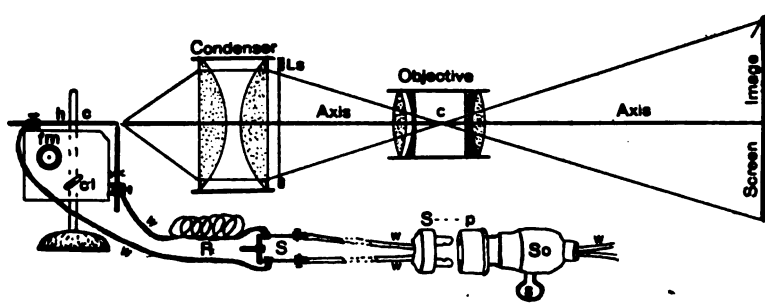

Fig. 6

Fig. 6. Diagram showing the wiring and the relation of the parts for lantern slide projection by means of the house electric lighting system.

The arc lamp and its wiring and connection with a rheostat and the house system is the same as in fig. 1, except that in this figure there is a knife switch (S) introduced to furnish means for turning on and off the current with absolute safety. Instead of a microscope there is present a projection objective for lantern slides (L S).

For projection and drawing with high powers when an ocular is used with one of the magic lantern condensers, figs. 9, 11, 13, one must use a special substage condenser or the converging cone of light from the larger condenser must be rendered parallel before

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it reaches the ordinary substage condenser. For this a concave lens is put in the path of the converging beam at a point so that the parallel beam will be of the diameter of the substage condenser. The focus of the concave lens to use for parallelizing the rays depends upon the focus of the condenser. If it is about 15 cm. from the lens face to its focue then a concave lens of 16 to 20 diopters

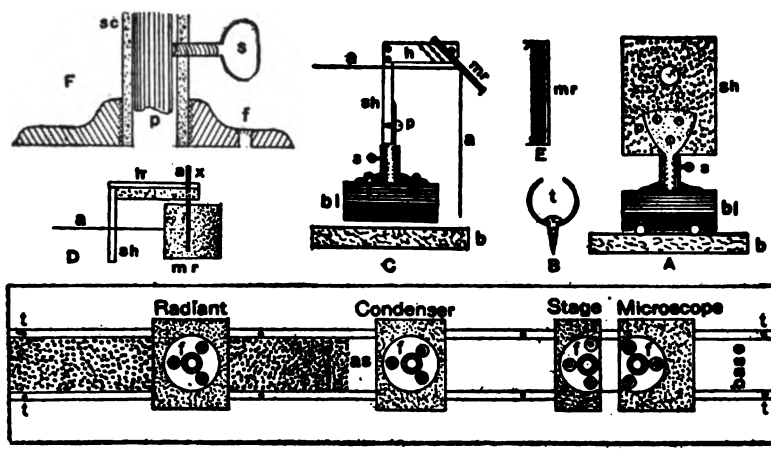

Fig. 10

Fig. 10. Diagrams to show how to construct an optical bench and the blocks with sockets for holding the different pieces of apparatus.

In the lower figure is shown a face view of the base board (base) with its tracks of brass rods (t-t), and with the blocks with their sockets for receiving the different pieces of apparatus. Each block is independent and slides freely back and forth on the track. Under the block carrying the arc lamp (Radiant) is a covering of asbestos (as).

A. End view of the base board and its tracks (b) with a block (bl) for carrying the objective. The block is partly of wood (the blackened portion) and has V-shaped grooves in it which rest on the tracks. The upper part of the block is of sheet lead to give weight and stability.

The post is a bolt flatteded at one end (p) to fasten to the wooden shield (sh) which carries the objective. The lower end of the bolt is received by the socket and fixed by the set screw at the side (s).

B. Sectional view of the track showing how it is fastened to the base board.

C. Side view of an apparatus block (bl) showing how the drawing mirror (mr) is supported from the shield (sh) holding the objective. The axial ray of the image forming beam is also shown (a-a).

D. View from above of the drawing mirror and its support.

E. Section of the mirror showing how the glass is held in a copper casing.

F. Sectional view of the socket for receiving the post of the apparatus. It is made of a railing flange with a short brass or iron tube for socket. The set screw (s) can be put at any desired level. This flange is screwed to the top of the supporting blocks as shown in the lower figure.

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will answer. If the main condenser has a focus of 20 to 40 cm. (8-16 in.) then a concave lens of 8 to 12 diopters suffices. Indeed with a main condenser of 25 to 35 cm. (10 to 14 in.) one can get very good results with the ordinary substage condenser if no parallelizing lens at all is used, but the converging cone of light is directed into the substage condenser at a point where its diameter is that of the lower end of the substage condenser.

Use of the Small Drawing Outfits for Demonstration

In the evening or in a dark room these small outfits are admirable for demonstrations to small classes. For the purposes of demonstration it is better to remove or turn aside the reflecting mirror over the ocular, and then to use a screen of white cardboard. White paper is one of the best screens ever used. One can project images with the oil immersion with the screen one meter (3 to 4 feet) from the microscope, and thus make the image visible to classes of 10 to 20 standing or sitting near. For the oil immersion, of course the specimen would need to be very transparent. With the objectives of 8 mm. and lower powers, and oculars of x 3 or x 4 one can project brilliant screen images at a distance of 2 to 4 meters (6-12 feet) in a well darkened room.

Up to the present time three optical houses have brought out small lamps and arrangements for drawing by the light from the house circuit.

All have been tested fully by me personally, and all have been found effective. All work more satisfactorily in the evening or in a dark room or in a shaded corner. Below are given figures of these outfits, and in the explanations of the figures are brought out the special points of each.

The complete, small outfit of Leitz, exclusive of the microscope, costs 169 marks in Germany. If the duty must be paid, the cost is $68.00 in New York. (Fig. 12).

The Bausch & Lomb simple outfit costs $25.00 exclusive of the microscope. (Fig. 14).

The Apparatus of the Spencer Lens Company, exclusive of the microscope, costs $38.00. (Fig. 15).

With all, the various parts are sold separately, and any one interested could get the special circulars of the different houses with the prices of the separate parts.

If one already possesses some of the parts, and has a little ingenuity, a drawing outfit can be assembled in the laboratory or home which will answer all requirements at a considerable saving of expense, although it may lack some of the conveniences in the regularly made outfits.

If one works long at a time the rheostat gets pretty hot, and occasionally hot cinders fall from the burning carbons, hence it is wise to set the lamp and rheostat on a blackened sheet of asbestos.

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EXPLANATION OF PLATES

Plate XIX

Fig. 2. Photograph of the author's drawing outfit, for the house lighting system, arranged for evening or dark room drawing.

s-w. Separable plug and wires connecting the house lighting system with the arc lamp.

r. Rheostat in series (i. e. in one wire). It does not allow more than 5 to 6 amperes of current to flow.

l. Arc lamp with small carbons at right angles. There is a black disc at the end of the lamp-condenser tube to aid in getting the light through the microscope. The lamp is at right angles to the microscope, but it can also be used in the optic axis if desired.

m-s. Microscope mirror and substage condenser.

m. Tube of the microscope and a 45 degree mirror or prism to reflect the image forming rays down upon the drawing surface.

im. Image on the drawing surface.

sh. Shield of blackened card-board to cut off stray light from the drawing surface and the face of the observer. It was left in place about three fourths of the time of exposure of the negative, hence it appears as if transparent.

Fig. 3. Photograph of the author's drawing outfit for the house lighting system with a black, cloth tent over the end of the microscope and the drawing surface, for use in a light room.

s-w. The cap of the separable plug and the two wires from the same to the arc lamp. One wire is cut and the two ends joined to the rheostat so that the current shall traverse the rheostat.

r. Rheostat in series; it does not allow more than five or six amperes of current to flow.

l. Arc lamp with condenser for giving parallel rays; it is at right angles with the miscroscope but may be used in the optic axis if desired; it is easier for many to get the light through the microscope with this relation than with the lamp in line with the microscope.

m. Mirror of the microscope.

t. Tent of black cloth supported by a wire frame. It cuts off stray light from the drawing surface, and enables one to draw in a light room.

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Plate XX

Fig. 5. Photograph of the author's apparatus for drawing objects the size of lantern slides.

The illumination can be by the ordinary heavy lantern slide current, or by the small current of the house lighting supply. If the current is direct, then the automatic arc lamp of the Bausch & Lomb Optical Co. can be used for currents from 5 to 25 amperes. The 5 ampere current is sufficient for drawing. If one wishes to draw on a horizontal surface, then a mirror is put beyond the objective. If the drawing is on a vertical surface, as for wall diagrams, then the mirror is removed.

a-a-a, axis; as., adjustable shelf attached to the table legs; b., the base board with track (see fig. 10); c, triple condenser with water cell; l, automatic arc lamp; l-s, lantern slide carrier; m, mirror beyond the objective; o, objective; r, rheostat of the theater dimmer type; s., table switch for turning the current on and off the lamp; w., wire cable from the supply; tw., triple wire to the arc lamp.

Fig. 7. Photograph of the author's apparatus for drawing with the microscope without an ocular or substage condenser.

The arc lamp is Mr. Albert T. Thompson's automatic lamp for direct current. It can be used on small currents, and up to 25 amperes.

This is the first automatic arc lamp for right angled carbons.

By means of the optical bench carrying all the apparatus, the different parts are pulled forward so that the microscope tube and mirror project over the drawing shelf. This is adjustable up and down for varying the magnification.

The stage of the microscope (st) is independent and contains a large glass water cell against which the specimen rests. It conducts away the heat from the specimen.

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Plate XXI

Fig. 8. Photograph of the author's apparatus for drawing with the microscope and a movable table with large plate glass mirror. a-a-a, Axial ray of the illuminating and image forming beam; b, base board of the optical bench; c, condenser with water cell; im, drawing surface where the image is projected; l h, lamp house. It was present only during a part of the exposure of the negative, hence it appears transparent, showing the hand-feed arc lamp within; m., the large mirror attached to the drawing table; r, rheostat. It is of the ordinary form; s, the double pole, table switch for opening and closing the circuit; w 1, 2, supply wire to the switch and from the switch directly to the arc lamp; w 3, 4, 5, (upper carbon) the supply wire to the switch, and from the switch to the one binding post of the rheostat (4); from the other binding post of the rheostat (5) a wire passes directly to the arc lamp (lower carbon). No current can go through the lamp without going through the rheostat with this arrangement; and with the double pole switch, the current is cut completely off the entire apparatus when the switch is open. The adjustable drawing shelf has an arrangement for moving up and down on metal ways which can be attached to any table, whatever the form of the legs. The supporting brackets are jointed so that the shelf can be let down when the large drawing table needs to be brought up close to the projection table. This method of moving the drawing shelf and lowering it is due to Dr. B. F. Kingsbury.

Fig. 9. Photograph of the author's apparatus for drawing with the large condenser, an ordinary microscope and an ocular.

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Plate XXII

Fig. 11. Edinger vertical drawing and photographic apparatus for use on the house current. Made by E. Leitz.

The arc lamp is of the Liliput form with small right angled carbons.

The lamp condenser is large, such as is used for lantern slide projection, hence large as well as small objects can be illuminated by it.

For convenience in feeding the carbons there is a rod extending down within reach of the artist.

The microscope and stage are separate and independently movable on the vertical optical bench. In addition to the lamp condenser there are two or more substage condensers of different foci.

The object is put on the upper side of the stage.

The microscope can be used with an ocular, or the draw tube and ocular can be removed from the large microscope tube, and then objectives alone used, thus giving very large fields.

If desired for projection on a vertical screen, the apparatus rotates on a central axis to the horizontal position.

The vertical position is advantageous for drawing objects which must remain horizontal, but for most microscopic specimens which can be put in a vertical position, the apparatus is less convenient than one of the horizontal outfits.

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Plate XXIII

Fig. 12. Edinger's drawing microscope with cloth tent. Made by E. Leitz, Wetzlar.

The lamp condenser is small, and composed of a single double convex lens at the end of a telescoping tube. If the tube is in, the beam is nearly parallel, if pulled out more or less there is a converging cone of light. The lamp is supported on a vertical tube and can be set at any desired height and at any angle. As shown, the mirror is used to direct the light up through the microscope.

The microscope itself is inclined at 45 degrees and the mirror at 22½ degrees, thus directing the light vertically down upon the drawing surface.

It is necessary to be careful in giving the microscope and the mirror the right inclination or the image will be distorted. The correct adjustment is more difficult than with the horizontal microscope.

For drawing in a light room a cloth tent is provided and is supported above and on the sides by metal arches. If it is very light one can pull the cloth over the head as in focusing a camera. In the evening or in a dark room the cloth can be opened widely to expose the drawing surface.

This apparatus was demonstrated at the meeting of the Anatomische Gesellschaft at its Leipzig meeting, April, 1911. With it one can draw with objectives of 50 mm. focus through the scale to oil immersions.

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Plate XXIV

Fig. 13. Combined drawing and photomicrographic apparatus of the Bausch & Lomb Optical Company, for use on the house lighting system.

This is a kind of universal apparatus serving for drawing with the microscope, projection with a microscope and with a magic lantern; opaque projection, and finally for photographing with all objectives and with the microscope.

It can be used in a horizontal, an inclined or a vertical position. For drawing with the microscope in a horizontal position there is an adjustable drawing shelf with a cloth tent for shutting out daylight in a light room.

The large condenser enables one to use the apparatus on specimens of all sizes up to lantern slides.

Fig. 14. Simple drawing apparatus for the microscope, the Bausch & Lomb Optical Company.

There is a hand feed, right angled arc lamp for small carbons, wiring and connections for the house circuit and a rheostat which will not permit over 6 amperes of current to flow. The lamp condenser is in a telescoping tube so that either a parallel or a converging beam of light can be obtained.

The microscope is on a support giving a drawing distance of 25 centimeters (10 inches), and the drawing surface is enclosed by a metal shield to keep out stray light.

The lamp and the microscope are put in one line. For this the lamp is adjustable on a vertical support and it can be inclined at any angle.

If one finds it easier to use the mirror, and have the lamp at right angles to the microscope, this outfit lends itself perfectly to that arrangement.

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Plate XXV

Fig. 15. Spencer Lens Company's apparatus for drawing with the microscope.

This consists of a small arc lamp with the proper wiring, rheostat and connections for the house electric supply. The lamp has all the adjustments, and the condenser tube is telescoping so that the beam of light may be parallel or converging.

At the end of the condenser tube is a black disc for cutting off stray light and serving as a screen upon which the spot of light from the substage condenser can be thrown, thus serving as an aid in getting the mirror at the right angle to send the light through the microscope.

The microscope is supported on an adjustable shelf which can be raised or lowered on the vertical rods, thus enabling one to get any desired magnification.

The vertical supports for the microscope shelf serve to carry a curved metal band to support the cloth curtains to shade the drawing surface. There are two curtains and they hang freely, thus avoiding all interference with the hands in drawing. If one desires, the arc lamp can be put in line with the microscope and the mirror turned aside.

For a reflector beyond the ocular a prism is used, thus avoiding any defects of a mirror.

Fig. 16. Photograph of the author's large projection outfit arranged for use with a vertical microscope.

This shows that the microscope mirror turns the illuminating beam from the condenser up through the microscope, and that to get the image on a vertical screen in the lecture room it is necessary to use a second mirror or prism to direct the beam horizontally again.

The lamp is the new three wire automatic lamp of the Bausch & Lomb Optical Company. The feeding screws (hf) and the fine adjustment screws (fa) project out behind the lamp house (lh). The lamp house was left in position about three fourths of the time of exposure of the negative, hence it appears transparent, showing the arc lamp within. The window for observing the arc is opposite the ends of the carbons (g).

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DEPARTMENT OF NOTES, REVIEWS, ETC.

It is the purpose, in this department, to present from time to time brief original notes, both of methods of work and of results, by members of the Society. All members are invited to submit such items. In the absence of these there will be given a few brief abstracts of recent work of more general interest to students and teachers. There will be no attempt to make these abstracts exhaustive. They will illustrate progress without attempting to define it, and will thus give to the teacher current illustrations, and to the isolated student suggestions of suitable fields of investigation.—[Editor.]

A CONVENIENT APPARATUS FOR LABORATORY PHOTOGRAPHY

During the past seven years the writer has used with considerable satisfaction an apparatus that is well suited for use in photographing various types of biological specimens. Every well-equipped biological laboratory should be provided with an apparatus of some sort which will make possible the ready photographing of specimens when placed in a horizontal position. Doubtless many have exhausted their patience trying to get satisfactory pictures of bacterial cultures, fungi, flowers, insects, embryos, etc., which must be supported in a vertical position if an ordinary tripod is used, and many makeshifts are frequently brought into play, and these oftentimes without the desired results. It was a few trying experiences that led to the construction of the apparatus described.

The prototype of the apparatus constructed was found in the crude device described and illustrated by Smith[1] as a "simple apparatus for holding the camera in place when one wishes to photograph down." The apparatus shown in the accompanying illustration (Plate XXVI, Fig. 1) consists of two essential parts: the horizontal stage, a piece of French plate glass, 2x3 ft., supported six inches above the platform carrying the backgrounds; and the rigid upright support permitting the adjustment of the camera at any desired height above the stage. The plate glass is elevated 6 inches above the platform and rests upon a support at the foot of the upright for its entire width and is held in place at the opposite end by two wedge-shaped corner posts. All the surfaces in contact with the glass are padded with strips of felt. The upright support, 8 inches wide and 6 feet high, is firmly braced to the narrow rear extension of the platform and is provided with a medium longitudinal slot

1. Smith, Erwin F. Bacteria in Relation to Plant Diseases. Vol. 1, p. 133. 1905.

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just large enough to carry a tripod screw. In photographing small specimens the camera can be attached directly to the upright support, but for large specimens it is necessary to have the camera removed from the upright. In order to secure this the apparatus is provided with a quadrangular frame the same width as the upright, and of such a size as to throw the camera over the center of the stage. The illustration shows a Premo, 4x5 camera in position. The quadrangular frame is held in position by two wooden screws and can be adjusted to any desired height, while the camera can also be raised or lowered upon the frame.

The platform is supported by five large, wood-roller, ball-bearing castors, three of which appear in the illustration. The apparatus constructed according to this plan is easily moved about the laboratory; it is light, but sufficiently rigid to prevent vibrations of the camera. It is always ready to use at a moment's notice, and long exasperating delays are avoided.

The object to be photographed is placed upon the plate glass stage and is thus held six inches above the background. By this means shadows are entirely avoided. Various colored backgrounds, which for purposes of record are numbered, should be provided. For these backgrounds sheets of bristol board, or better, picture matting with rough surfaces, may be satisfactorily employed. The Ingento convertible tripod attachment is sometimes used for photographing down, and is especially desirable for field work, but the apparatus here described is so far superior for laboratory work that it will repay the cost of construction many times.

The writer uses a long-focus, 5x7, Premo camera with various combinations of lenses for nearly all work. Specimens three feet in length may be photographed, or small objects may be taken natural size or enlarged six times or slightly more. The apparatus is adapted for use in various kinds of botanical, bacteriological or zoological work. The quality of work obtained by its use can be seen in Bulletin 135, "Symptoms of Disease in Plants" published by the writer from the University of Texas. Practically all the halftones in the above bulletin are from photographs taken with the type of apparatus here described.

University of Texas. F. D. HEALD.

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NATURE OF THE INTROMITTENT ORGAN OF THE ODONATA

In the great family of insects called Odonata, the males have a peculiar accessory sexual organ known as the intromittent organ.

This is situated on the rear segment of the thorax on the ventral side, and is used as an accessory organ during copulation. Before copulation the males, which emerge from the water before the females, fill the organ with seminal fluid from their own sexual organs. They are now ready for a mate and sally forth over some likely pond or stream watching for a female pupa which is just emerging from the water.

The female when ready to emerge casts her pupal skin and crawls up some convenient plant stem until she emerges from the water. The male seeing her thus grasps her by the neck with his anal forceps and carries her to some suitable place where she may dry herself ready for flight. When ready for flight they mate in the air. Again his anal forceps are brought into play; he grasps her by the neck and supports their combined weight in the flight. She now places the tip of her abdomen in contact with his thoracic claspers, while with the intromittent organ the sperms are transmitted.

It is quite an interesting problem how this intromittent organ arose in the phylogeny of the insect, and what organs and functions were modified in producing the effect.

Originally the sexual organs of the male, at least the external accessory organs, must have been anal in situation as in most of the insect families.

Evidently in this case the forceps and this functional development for carrying the female by the neck rendered it more difficult for the female to get her body around into proper position for receiving the male elements. Perhaps the extreme elongation of the abdomen in both sexes also entered into the modification.

So, simultaneously with the development of the forceps and the elongated abdomen, must have developed the habit of the male of first emitting his semen on the appendages of the thorax.

Now right here lies the peculiar discovery noted in this paper; the intromittent organ is jointed in the manner of insect legs, and the writer raises the question as to whether it is homologous with a pair of legs. This organ consists of four well defined joints, which may

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be seen in the photo and are numbered a, b, c, d. In case this is a true leg structure the segments would be (a) coxa, (b) femur, (c) tibia, (d) tarsus. See plate XXVI, Fig. 2 and text figure 1.

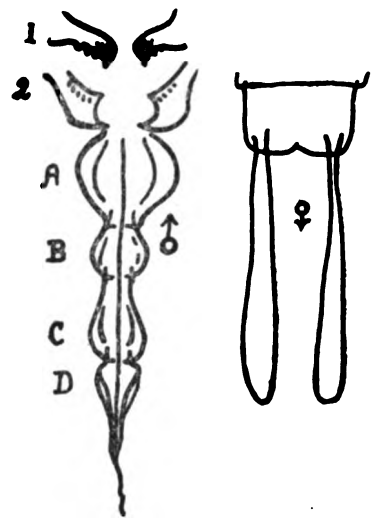

Fig. 1. Diagram of male (left) and female (right) accessory abdominal appendages for copulation. (See also Plate XXVI, Fig. 2).

The question immediately arises, did not the Odonata once have a thorax of four segments, and does not this leg structure represent a rudimentary fourth segment?

There is a good opportunity here for investigation of larval and nymph forms of the different species to look for evidence for or against this theory of the origin of the organ.

This leg structure is paired, forming a single median organ, the inner opposed surfaces of which are hollowed out forming a cavity in which the seminal elements are retained. The terminal segments or tarsi are prolonged into a minute tapering tube. The two preceding segments of the thorax have a pair of clasping organs by which certain appendages of the female abdomen are grasped to enable her to retain her difficult position during copulation. See the diagram of the ventral aspect of the male thorax where the claspers are designated 1 and 2, and the female accessory abdominal appendages which slip under the male claspers (text Fig. 1).

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These two claspers on the male thorax do not show any evidence of joints and are evidently simple modifications of the hypoderm of the segments on which they are located.

These claspers present certain arrangements of external sense organs which vary in the different species.

It my be that some of the readers of the Transactions will have a different theory of the origin of this structure and its nature; if so, we should much like to hear from them and get other facts bearing on the embryology of the organ.

Battle Creek, Mich. E. W. ROBERTS.

SUGGESTIONS FOR AMATEUR MICROSCOPISTS

1. *Whole Mounts*—Many interesting and beautiful specimens may be made from small insects, by steeping in concentrated carbolic acid solution, and mounting entire without compression. This agent is used especially to render transparent such subjects as acari and lice, parasites of birds, as it clears the outer skin and renders the internal organs visible. Crystallized carbolic acid liquified by heat, with the addition of 1 drachm of glycerine to 4 ounces of the melted carbolic acid, will not become solid again.

The acaridae or mites give interesting studies in color, form, and variety. For literaure, see *Science Gossip,* or the monograph on the Oribatidae in the Ray Society by A. D. Michael.

2. *Internal Organs of Cockroach*—The members of the cockroach family can easily be obtained, and furnish interesting material. To kill, put a few drops of chloroform on blotting paper and cover together with animal. It is well to select some special and definite line of study,—as, say, the abdominal viscera,—after having studied the external parts.

To study the viscera of course requires dissection. The following suggestions will aid the beginner:

Remove all external appendages, as wings and legs, with scissors. To make a dissecting dish, take a piece of gutta percha, such as is supplied for boot soles, cut a piece 4½x2½ inches, soften in hot water, bend the edges so as to form a dish or pan. Drop into this a mixture of paraffin, white or blackened by lampblack, as preferred. Before this is entirely set the back of the insect may be

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pressed gently on the surface. This will do away with the need of pins. When this is set cover with about 30-50% alcohol and dissect.

First remove the chitinous covering by shallow cuts along the side with fine pointed scissors. Don't injure organs within. Raise the skin gradually with forceps, beginning at the thoracic end, gently clearing away the attachments of the trachea with *new* steel or with gold plated needles. Rusty tools tear delicate tissues. The trachae, the intestine and its outgrowths, the genitalia, etc., may thus be removed, stained as desired, and mounted in dilute glycerine, in which form it may be kept for extended examination.

If it is desired to study the nervous system the dissection should be made from the back instead of from the belly.

3. *Study of Variation*—There is much of value and interest to the general student in the study of the variation that occurs in corresponding organs in different animals. Take, for example, some peculiar glandular bodies found in the rectal pouch of various insects, known as the *rectal papillae*. These are connected with the function performed by the kidneys in higher animals,—excretion of uric acid. Well formed crystals are frequently found in the pouches. In the blow-fly they are 4 in number, of a pyramidal shape, projecting from the wall of the rectum. In the ear-wig there are 6 of the papillae which are of a circular shape; in the flea there are 6, but oval; in the bee they are 8 in number and elongated. The student will find, after once undertaking such comparative studies, an abundant field of interest open up to industry and intelligence.

4. *Using Newly Hatched Specimens*—Newly hatched insects are usually better than the older battered specimens for the study of many features. For example, the wings of butterflies are more beautiful and more representative if the animal is removed from the chrysalis before it has time to spread its wings. So the mouth parts of the blow-fly,—as the tongue,—can be handled and mounted more readily by the usual methods, when taken thus early, than by waiting until it is old and stiff.

A freshly hatched blow-fly, fed on a mixture of cochineal and sugar, will be found on dissection, to have its whole digestive tract

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stained with carmine. Thus making more instructive and easy the dissection of it.

5. *To examine a living flea*—Insert a living flea under a tumbler, with some blotting paper on which are a few drops of chloroform. As soon as it becomes entirely still, fix it on a white card by laying its side in a minute drop of balsam or other transparent gum. When the eflect of the anaesthetic has passed away the drying gum will hold the animal fast, and the motion of its legs and mouth parts may be studied. The problem is one of determining how long to allow the anaesthetic to act, and the rate of hardening of the gum.

6. *Non Rusting Needles*—Ordinary steel needles rust readily and corrode in various media. This can be prevented by coating them with gold. This may be done by shaking up an aqueous solution of gold chloride with sulphuric ether, which, taking up the gold from the solution, will deposit it on any steel which comes in contact with it. Surgeons' needles, especially those that are flat or triangular, if ground, sharpened and highly polished, are most useful instruments for minute dissection when gilded as above. Rusted implements will catch on delicate tissues, and often spoil one's preparations.

It is to be remembered that excellent needles for use in corroding reagents may be made by drawing out glass rods to the fineness of a needle point, over a spirit lamp.

7. *Simple life cell*—Take a slip of cork, such as is used for pinning insects in museums. Cut it the size of your microscopical slides. Make an oval hole, about 1x¾ in. in diameter, thru the center, allowing the sides to taper slightly. Place the cork between glass slides, interposing a pad of wet blotting paper (with a corresponding hole in it) between the bottom slide and the cork. After placing the organisms within, the whole may be bound together by two elastic bands. Podurae and other small animals, not strictly aquatic, kept in these damp cells and fed on oatmeal, or other suitable food, will often thrive perfectly well, and may be studied at any moment. In this way extended studies of habits and life histories may be made. [From S. J. McIntire].

VIDA A. LATHAM, M. D.

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PRELIMINARY NOTICE

A further study of 125 cross sections of the femora of as many lower animals has been continued in the American Museum of Natural History, New York, during the present summer. The list includes amphibians, reptiles, birds and mammals. This makes over 300 femora so far examined, one hundred of which are human.

Important variations occur. The lower animals furnish the key to the surprising variations which are found in man. The amphibians are pretty true to their lamellar type. The reptiles seem to show divergence. The lizard group retains the amphibian lamellae, the alligator and some turtles have departed from it and show a crude system formation. Some birds conform to the lamellar, some to the laminar and some to the Haversian system type. A much larger number of mammals belong to the laminar type than was expected. Mammalian species often show a high and low type. For example, the African Elephant is composed entirely of Haversian system, high; the Asiatic, of Haversian systems, laminae, and lamellae in about equal parts, low. The hippopotamus, rhinoceros, giraffe, wart hog, water buffalo, camel, armadillo are low.

It is the intention of the writer to publish articles on the subject as soon as the sections can be drawn and described.

Creighton Med. College. J. S. FOOTE.

MICROBIOLOGY

This compact manual, which is now in its second edition, is an exceedingly timely resumè of a field which is of prime interest to members of this Society. The book is the product of a large number of collaborators, whose work has been brought together under the editorship of Professor Charles E. Marshall. While such books are always subject to some unevenness and repetition and lack of unity as compared with the work of a single author, there is here at least a compensating gain in authoritativeness in a wide range of material.

The book is divided into three general parts: Morphology and Culture of Microörganisms; Physiology of Microörganisms; and Applied Microbiology.

The editor has made an effort to present the fundamental facts

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and principles of the subject in such a way as to "show how these principles fit into subjects of a more or less strictly professional or practical nature." The relation of these microörganisms to Agriculture and to Domestic Science is treated at length and well.

In the morphological part we naturally have chapters on Molds, Yeasts, Bacteria, Protozoa, and the so-called invisible microörganisms. The physiological section includes Metabolism, Effects of Physical and Chemical Conditions on the Microörganisms, and their mutual influences. Under applied microbiology are such divisions as microbiology of the air, of water and sewage, of the soil, of milk and milk products, of various special industries, and of the diseases of plants, of animals and of man.

A brief history of the advance of microbiology opens the volume.

FEEDING HABITS OF MACKEREL

Bullen (Jour. Mar. Biol. Assn., June 1912) gives some conclusions on the feeding of mackerel in the English Channel. It is claimed that the mackerel feeds in two ways: "First, by a system of filtration upon plankton organisms, and secondly upon prey of a large character which is hunted by sight." From March to June the mackerel were feeding exclusively on plankton,—first vegetable, and later the general zoôplankton. The author, by examination of stomachs of the fish, finds that there is considerable evidence for believing that they are incapable of assimilating the larger prey when feeding largely on the minor forms of plankton. Later still they passed to larger zoôplankton and to such larger animals as were presented. It is concluded that there are two main types of the active "selective" feeding, and that the mackerel can subsist on these for reasonable periods of time, irrespective of the season. One of these is the selection of individual prey; the other is the selection of plankton organisms where they occur in great numbers, even tho the individual organism is too small for the mackerel to distinguish. These conditions apparently determine the movements of the mackerel and the method of catching them, and a knowledge of the facts may well assist in an understanding of the problems of the fisheries.

Microbiology for Agriculture and Domestic Science Students. Edited by Charles E. Marshall. Illustrated; 724 pages. P. Blakiston & Co., Phila. Price $2.50.

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KALA AZAR AND BED BUGS

There has been a disposition for some years to seek to fasten on the bed-bug the responsibility for transmitting some of the infections diseases. The habits of the animal lend decided substance to these expectations and the odium in which it is held doubtless makes its case the more hopeless.

Capt. W. S. Patton, I. M. S., (Ind. Med. Gaz., Feb. 19, 1912), reports that he has, by feeding *Cimex rotundatus* and *C. lectularius* on a case of Kala Azar, in whose blood the parasite had been identified, discovered an extended development of the parasite in these bugs. He also discovered that in bugs, in which the developing forms are present, again fed on the blood of a Kala Azar case, the flagellates are destroyed within 24 hours. However, if the bugs are not fed the second time the development goes on and is completed by the 10-12th day after the single feed. The parasite goes thru its complete cycle in both species. By the 7th-9th day the bug swarms with the flagellate stage in masses of rosettes. It is also claimed that the bugs do not contain, naturally, a flagellate.

CELL SIZE AND NUCLEAR SIZE

Conklin (Jour. Exp. Zool. Jan. 1912) in an elaborate paper based on a series of experiments and observations on *Crepidula* and *Fulgar* gives a most interesting series of conclusions concerning the size of cells and nuclei. Among these may be mentioned:

1. Inequality of cell division is due to internal causes rather than to pressure from without; and the controlling factors within are more intimate than the mere presence of metabolic substances such as yolk.

2. The size ratio between plasma and neucleus in the different blastomeres of an egg is not constant nor self-regulating; but seems to depend rather on the rate of cell division.

3. The inciting cause of cell division seems to lie in the coincidence of centrosomal, chromosomal, and cytosomal rhythms.

4. The size of the nucleus is dependent upon at least three factors: the initial quantity of chromatin; the volume of the cytoplasm; the length of the resting period.

5. In *Crepidula* the volume of cytoplasm more than doubles during the passage from the 1-cell stage to the 24-cell stage; the

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yolk decreases in volume nearly one-half in that time; and the entire embryo has less mass at the 24 than at the 1-cell stage. This shows that the protoplasmic growth during cleavage occurs at the expense of the yolk.

6. The average increase of protoplasm for each division in early cleavage (32 cells) is 6 per cent; of nucleus, 5-9 per cent; of chromatin, 8 per cent.

PROTOZOA IN HAY INFUSIONS

Woodruff (Jour. Exp. Zool., Feb., 1912), discusses a number of series of experiments on hay infusions with a view to determining the sources and sequence of their protozoan population. To determine the sources, he (1) used sterilized hay and water, exposed to air; (2) sterilized water with fresh hay, and air excluded; (3) ordinary tap water, with sterilized hay and air excluded; and (4), as controls, fresh hay, tap water, and loosely covered vessels. The experiments, which are valuable to the ordinary laboratory worker, furnish the following conclusions:

1. Air, water, and hay are all sources of protozoa in infusions,—the air being least, and the hay most, important. But ordinary hay, added to ordinary tap water, while furnishing some protozoa, will not produce a sufficient number of representative protozoa for the study of the full sequences.

2. In order, therefore, to study standard sequences it is necessary to "seed" the infusions with matter from general laboratory cultures. In such "seeded" infusions a definite sequence of appearance, of dominance (or maximum) and of disappearance was observed. The sequence of appearance at the surface of the infusion is as follows: Monad, Colpoda, Hypotrichida, Paramecium, Vorticella, and Ameba.

3. The middle of the infusion is inhabited chiefly by free-swimming types brought there by over crowding at the top and bottom, and does not manifest so definite a sequence.

4. The appearance, in appreciable numbers, of any of these types (except Ameba), at the bottom of the infusion, coincides with, or quickly follows, its surface maximum,—and seems to indicate the beginning of its decline.

5. As biological elements entering into the determination of

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the sequence may be included: the relative power and rate of division among them; the occurrence of the most satisfactory food conditions; specific excretion products, modifying the character of the water.

Fine (in the same Journal) makes a study of the chemical properties of the hay infusions and concludes that there is no intimately mutual relation between the sequence of the protozoa and the course of titratable acidity produced by the action of bacteria on the acid-yielding materials of the infusion.

INTERNAL FACTORS INFLUENCING SEX IN HYDATINA SENTA

Schull (Jour. Exp. Zool., Feb., 1912), summaries some studies on the life cycle of *Hydatina senta,* as follows:

1. Long continued parthenogenesis is accompanied by a progressive decrease in the proportion of male-producers.

2. A similar decrease occurs in the size of family produced,—tho the author states that there seems to be no correlation between these two declines.

3. Individuals hatched from fertilized eggs are not only all females, but are all female-producers.

4. The sex is determined a generation in advance. That is to say, whether a given female is to be a male-producer or a female-producer (so far as the manure culture is concerned) is irrevocably decided during the growth period of the parthenogenetic egg from which the female hatches.

REINVIGORATION OF PARTHENOGERIC STRAINS OF HYDATINA

Whitney (Jour. Exp. Zool. Apr., 1912), finds in strains of this organism whose reproductive powers had declined thru 384 parthenogentic generations, extending over a period of 29 months, that *inbreedings* of closely related individuals produced a slight increase in their reproductive powers; that *cross-breeding* of two such weakened races (altho originally derived parthenogentically from the same stock) produced a sudden and pronounced increase in the rate of reproduction of the ensuing race.

CAN SPERM CELLS DEVELOP WITHOUT THE EGG?

Loeb and Bancroft (Jour. Exp. Zool. Apr., 1912), raise this interesting question and undertake to nurture spermatozoa in cul-

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ture media. This experiment is the natural correlative of those which have shown that many ova may be stimulated artificially to produce embryos. In these studies the sperm cells of the chicken were used and were cultivated in egg yolk, egg albumen, chicken blood serum, and Ringer solutions.

It was found that spermatozoa did undergo some transformations. These include the shortening of the head, the formation of a vesicle about the head and middle piece, the dispersal thru the vesicle of the matter of the head, the gradual reformation of the chromatin into objects suggestive of chromosomes.

On the whole, while no evidence has been found that division can take place in the sperm outside the egg, the results thus far may be comprhended in the statement that the sperm is able to organize itself into something much resembling a nucleus.

ADAPTATION OF FISH TO TEMPERATURE

Loeb and Wasteneys (Jour. Exp. Zool., May, 1912), inquire into the phenomena associated with adaptation to changed temperatures. It has long been known that animals may gradually be rendered immune to temperatures which applied outright would cause death.

In these experiments it was found that fish could be rendered immune to the hurtful eflects of a sudden transfer to water of a temperature of 35°C by being placed for 30 hours or more in a temperature of 27°. Similarly they may be made immune to a temperature of 39°C. The ability to endure water at 35° was not lost or weakened by keeping the fish at a temperature of 10°-14° for 33 days after having been acclimatized to water at 27°; nor by keeping them for two days at a temperature of 0°.4C, after their two days exposure to 27°.

It was also found that fish could stand a sudden increase of temperature better with a higher concentration of sea-water up to a certain maximum solution—beyond which the ability again declined. This is thought to be due to specific effects of the salts rather than to changed osmotic conditions.

EFFECT OF CONTACT AND TENSION ON TENDRILS

Brush (Bot. Gaz. June, 1912), finds that the tendrils of Passi-

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flora which are actually functioning in supporting the plant are possessed of greater breaking strength, all along their length, than tendrils of similar age that are not functioning. According to the conclusions of the author there are two different factors, contact and tension, which combine to produce the increased strength. The effect of contact of the tendril with supporting objects is to increase the numbers, and the thickness of the walls, of the cells of the xylem; while the effect of tension is to produce a thickening of the walls of the pith by which it comes to function as a real mechanical tissue. It has never been considered that pith achieved any mechanical value.

TO MOUNT DISSECTIONS OF MOUTH-PARTS OF INSECTS, UNDER ONE COVER-GLASS, WITHOUT CEMENT*

1. Dissect out the various parts; place them on a slide; put another slide on top; tie with cotton, and put into methylated spirit for 24-48 hours, according to size of specimens.

2. Remove one of the slides, carefully detach the parts, and place them in clove oil (or terpineol: V. A. L.) to clear. Then cover with turpentine.

3. Place the mouthparts on a slide in the desired order, cover all with a cover glass which must be held securely on with wire clip. Allow thin Canada balsam in benzole to run under cover. As the benzole evaporates add more of the thin balsam, until the space is filled.

4. Allow preparation to dry a week or more. Remove clip, wash away excess balsam with camel's hair brush in benzole. When completely dry apply coat of shellac varnish, if desired, to edge of cover glass.

TERPINEOL: A NEW CLEARING AGENT

This agent can be used for all microscopical purposes including celloidinzed sections. The oils are chemically known as terpines, terpene alcohols, sesquiterpenes, and a few others with their esters, such as terpinyl acetate. All these substances are found in varying amounts in one and the same oil.

*Personal communication from Martin J. Cole, London, to Dr. V. A. Latham.

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$$\text{Terpineol}—CH_3\text{-}C\left\{\begin{matrix}CH—CH_2\\CH_2—CH_2\end{matrix}\right\}CH—C\ (OH)\ (CH_3)_2$$

very much resembles cineol which has as its chief constituent oil cajeput, oil eucalyptus, and a few other oils. Altho terpineol is not itself present in these oils, its derivatives, such as cineol, terpinyl acetate are the chief constituents. The chief draw back to most of the oils is that they are not universally applicable to microscopic purposes, and so several kinds must be kept. They often, too, dissolve celloidin and the anilim stains; and are high priced.

The new terpineol, which is manufactured synthetically from oil turpentine, replaces oil of bergamot by clearing celloidin sections, having a perfect clearing action; dissolves paraffn; does not dissolve anilin colors; has a refractive index of 1.49; and is only 1-5 the price of bergamot.

V. A. L.

DEVELOPMENT OF SPERM IN HYBRIDS

Pall (Arch. Mikr. Anat. 1911) report studies on the spermatogenesis in hybrid ducks and in young mules, in comparison with the stages characteristic of the pure parental strains. The early stages of development in the testis appears to be normal, so far as microscopic technic can determine; but for some reason the dividing cells in the last division stages, are unable to form perfect spermatozoa. This is one of the reasons at least for the frequent infertility of hybrids.

FUNCTION OF THE MALE ACCESSORY REPRODUCTIVE GLANDS IN MAMMALS

Iwanov (Arch. Mikr. Anat. 1911) believes that there are probably two functions to the prostatic fluid and other secretions produced by the glands accessory to the male reproductive structures in mammals. His conclusions are based upon experimentation. The principal function he believes to be one of diluting the seminal fluid proper and of furnishing volume by means of which emission is facilitated and a medium of motion insured. Secondly, he believes that there are elements in the prostate secretion, particularly, that serve to stimulate the sperm cells to higher activity,—coincidently with shortened life.

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INHERITANCE OF LEFT HANDEDNESS

Jordan (Am. Breeders' Mag. 1911) reports studies of left-handedness of nearly 3000 individuals belonging to 78 lines of descent. The evidences are that left-handedness is inherited, but apparently not in accordance with the Mendelian principles. He believes that left-handedness is correlated with greater size and weight of the right hemisphere of the brain.

EFFECTS OF DARKNESS ON GOLDFISH

Ogneff (Anat. Anzeig., 1911) describes changes in gold fish which have been kept three years or more in darkness. The principle points noted are:

1. The golden appearance gives place to darker color, due histologically to the development and spreading of black chromatophores which cover the crystals that give the normal shimmer.

2. The ovaries become more compact and degenerative changes set in.

3. The eye undergoes a distinct series of degenerative changes. All the cells become smaller; the layer of rods and cones disappears altogether; the pigment processes that normally penetrate between the rods and cones fail. Functionally, these changes result in blindness,—all within the life of the single individual.

A NEW ULTRA CONDENSER FOR VIEWING ULTRA-MICROSCOPIC PARTCLES

The Ultra Condenser has been devised by Dr. Felix Jentzsch*, of the scientific department of E. Leitz, Wetzlar and serves for ultra-microscopic observations, especially for the examination of gases and fluids. It is not available for the examination of solids.

The designation *Ultra Condenser* signifies that the apparatus is an appendage which renders an ordinary microscope available for ultra-microscopic observations.

*Physikalische Zeitschrift, Vol. 11, pp. 1000-1001 Verhandlungen der deutschen Physikalischen Gesellschaft, Vol. 12, pp. 991-993, 1910. Paper read on the 22nd Sept., 1910, before the German Congress of Science and Medicine at Koenigsberg.

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Whereas in all previously devised methods the illuminating pencil enters from one side only, this condenser causes the light to converge to one point from all sides. This is achieved by means of two glass bodies having each a reflecting spherical surface, as shown

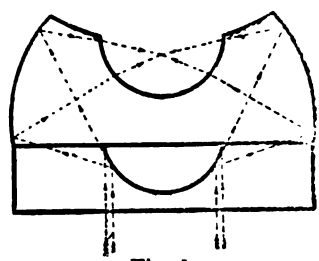

Fig. 1

in Fig. 1. It will be seen that every ray is reflected four times, twice before the particle becomes a centre of disturbance and twice after this occurrence. In this way the whole of the rays, with the exception of a very small portion, leave the ultra-condenser on the same

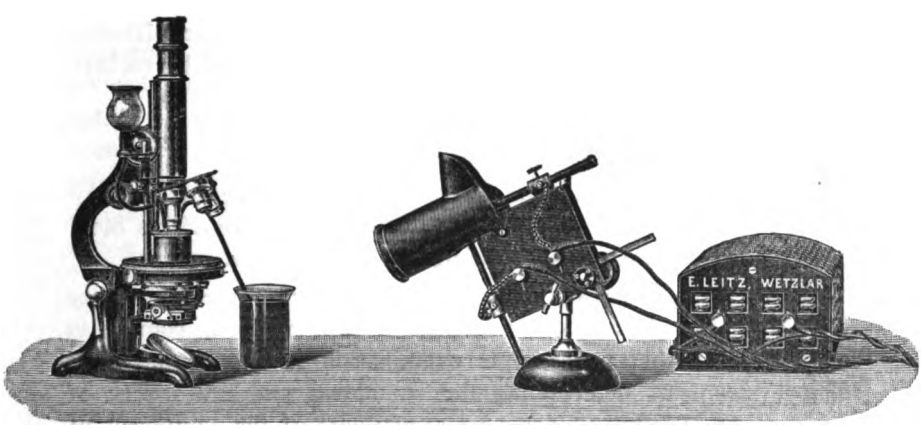

Fig. 2

side on which they entered it. The point of convergence is surrounded by a hollow sphere which is ground out of the upper body of glass and which is provided for the accommodation of the gases, vapours, or liquids which are to be examined.

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The whole is firmly cemented into a metal box fitted with a bayonet jointed and rubber faced cover, by means of which the hollow can be closed tightly. Gases and liquids may be led in through two small tubes. The centre of the cover is fitted with a small disc of quartz, which serves as an observation window. It goes without saying that there is no occasion to introduce an immersion fluid of any kind.

Figure 2 demonstrates the position of the Condenser when used in connection with the microscope.

HONORARY DEGREE TO MR. E. LEITZ, JR.

The University of Giessen has conferred on Mr. E. Leitz, Jr., director of the microscopic concern, Ernst Leitz, Wetzlar, Germany, the honorary degree of doctor of medicine. The title in the certificate reads:

"Dem zielbewussten Leiter der Weltfirma Leitz und weitblickenden Organisator auf sozialem Gebiet, dem talentvollen Foerderer der Mikroskopie, Mikro-photographie und Projektion, dem Schoepfer neuer Instrumente und Konstruktionen, der durch seine reichen Zuwendungen von optischen Apparaten die Weissenschaftlichen Institute in hohem Masse unterstuetzte, ausbauen und befruchten half, fuer seine Verdienste um die Universitaet."

METALLURGICAL APPARATUS

C. Reichert, Vienna, emphasizes the importance of Metallography by the issuance of a special catalog descriptive of his older and more recent apparatus for microscopic analysis of metals.

Formerly such work was confined largely to the laboratory of the research chemist or metallurgist, but since it is coming to be appreciated that microscopic examination is one of the most efficient means of determining the soundness and uniformity of metals, these instruments are a necessary part of the equipment of contractors, engineers, as well as of the manufacturers of the metal and those who manufacture special products from the metal.

In addition to the older models originated by Prof. Rejto and the auxiliary appliances used with these, the body of the catalog is given to the discussion of the principles of a new metallographic

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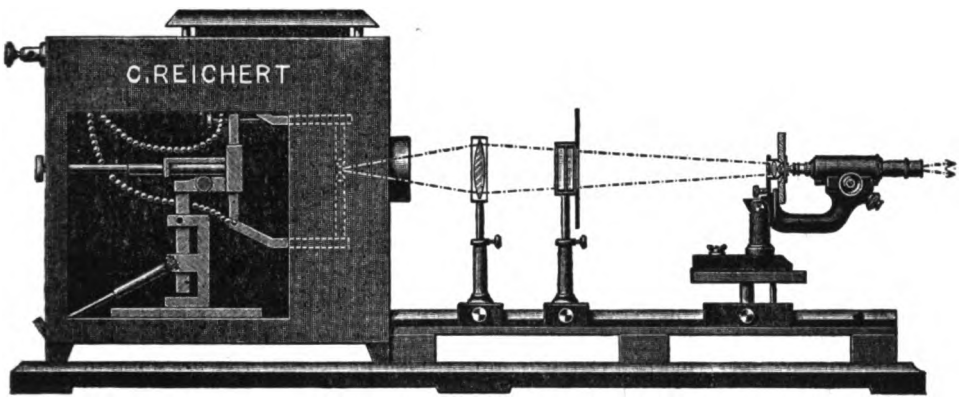
microscope, with reflecting camera, photomicrographic apparatus, and the like.



Reichert Fluorescence-Microscope

This new pattern secures a more perfect illumination of the metal surface, requires only one prepared surface, is more convenient for the rapid taking of a series of photographs, and has a more convenient form of slow adjustment. It would seem that the device offered reaches the limit of possible convenience in passing from optical observation to photographing. The catalog describes also a special microscopic apparatus for the measurement of the comparative hardness and tenacity of various materials. The apparatus was devised by Mr. J. A. Brinell. The catalog may be had on application.

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NECROLOGY

WILLIAM HENRY WALMSLEY

(*Born October 12th, 1830—Died October 22nd, 1905.*)

W. H. Walmsley was descended from Thomas and Elizabeth Trotter Walmsley, who came from Settle, Yorkshire, England, at the time of William Penn's first visit to America and purchased land on the Neshaminy Creek, Bucks Co., Pennsylvania.

William Henry, the eldest son, was born October 12th, 1830, at Byberry, Bucks Co., Pa. He was educated at Westtown Boarding School. While there he became much interested in the study of Botany and other science; But at the age of eighteen he was obliged to leave school abruptly on account of the death of his father—to begin his business career in the wholesale dry goods house of Barcroft and Beaver in Philadelphia. On November 23d, 1854, he married Annie M. Bunting, daughter of Jacob Parker Bunting (Alderman of New York City). Being a member of the Society of Friends—he was read "out of meeting" for daring to wed outside of the Sect:—later, the society wanted to reinstate him to good standing, but as he had joined the Church wherein his wife worshipped, he preferred to remain an Episcopalian.

In Providence, R. I., about 1865, he became interested in the study of the microscope and the preparation and mounting of slides, soon taking high rank with such men as Dr. J. G. Hunt. He was especially successful in making slides of arranged diatoms, insects and vegetable tissues.

His great love and success in the study of *Fungi* was manifested in the discovery and classification of at least 1500 varieties, within walking distance of Capon Springs, Virginia. He was engaged at the time of his death with Drs. Macfarlane and Harshberger in the preparation of a work on Relation of *Rag Weed* to *Hay Fever,* and also had all the material ready to write a book on the *Mushroom.*

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In 1870 he became a partner in the firm of James W. Queen & Co., of Philadelphia, giving his entire attention to the Microscopical Department. In 1877, he associated himself with R. & J. Beck of London, England; and later, upon the death of the Becks, he carried on the American branch under his own name for many years.

In addition to inventing many devices and improvements to the microscope and its accessories, he was an enthusiast in photography and did much to perfect and simplify former methods, and great credit is due him for his patience, perseverance and skill, especially in the field of photo-micrography. He was also much interested in the development of acetylene gas for use in photo-micrography and the manufacture of generators, and a special form of burner for using the gas.

Later, he was connected with the Pepper Laboratory of the University of Pennsylvania. Under his personal supervision was installed and equipped one of the finest outfits of photo-micrographic apparatus, everything of the latest tyye for research work.

In 1902, he wrote The A. B. C. of Photo-Micrography, a practical guide for beginners which was very favorably received and is used extensively, not only in America and Europe, but all over the world where the English language is used.

He held membership in the following societies: American Microscopical, of which he was a charter member; a Fellow of the American Association for the Advancement of Science; life member of The Academy of Natural Sciences of Philadelphia; Royal Microscopical Society of England; Botanical Society of the University of Pennsylvania; Honorary member of the Microscopical Societies of Chicago and San Francisco; and of the Photographic Society of Philadelphia.

The career of William Henry Walmsley presents a personality and character worthy of remembrance, devoted to his home and to his work; honorable, conscientious, kindly and sympathetic, always ready and willing to extend a helping hand; so genial and so cordial, that he endeared himself to the hearts of his many friends.

J. Frederick Herbert, M. D

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NOTICE OF ANNUAL MEETING

The Annual Meeting of the American Microscopical Society will occur in Cleveland, Ohio, on Dec. 31, 1912, and Jan. 1, 1913. The Executive Committee will lunch together at 12:30 p. m. Dec. 31, at the University Club, and the business meeting will occur at 3:30 p. m. Jan. 1, at which time the annual election of officers will take place. The place of the business meeting has not yet been determined. Members will find it scheduled in the general program of the A. A. A. S. The Headquarters will be Hotel Euclid, Euclid Avenue and East 14th Street.

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TRANSACTIONS
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Vol. XXXI OCTOBER, 1912 No. 4

SOME AMERICAN *LEBERTIA*

By Ruth Marshall

The genus *Lebertia* of the water-mites is easily recognized by the character of the epimera. It belongs to a small group of genera, the subfamily *Lebertiinae,* characterized by the union of the four pairs of epimera into a single group, with their more or less complete fusion. This forms a shield which covers a large part of the ventral surface of the body.

In *Lebertia* the first and second pairs of plates of the two sides are in contact, while the third is partly fused with the second and fourth. The third and fourth diverge from the median line, and in the bay thus formed lies the genital area. The latter consists of two oblong plates, each with three acetabula. The sexes are alike. The covering of the rest of the body is soft or thickened, striate, minutely papilliate or developing bits of chitin.

The palpi are small and leg-like; the second joint is stout, the fifth is very small, and all bear bristles or hairs. The legs increase markedly in size from the first to the fourth, and all are tipped with claws. They bear many stout bristles, and sometimes swimming hairs.

Dr. Sig Thor, the Norwegian hydrachnologist, who has made the most extensive studies in the *Lebertia,* divides the genus into six subgenera; however, the characters which separate the groups seem rather small and inconstant.

Over sixty species have been described; only three of these are from other regions than European, these being from Kamts-

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chatka. *L. porosa* Thor, a widely distributed European species, has been found in Siberia. *L. tauinsignita* (Leb.) and *L. insignis* (Neum.) were reported by Doctor F. Koenike from Canada; but Doctor Thor thinks that these were not identical with the European forms. Three species are described in the present paper, two of which appear to be new. The *Lebertia* inhabit the colder waters, and this accounts for their very meager occurrence in the author's large collection of water-mites, which came chiefly from the Mississippi basin. One species, however, was found in the Waupaca Chain-o'-Lakes, lakes of glacial origin, in eastern Wisconsin; but the other two came from mountain lakes of the West. For the latter, the author is indebted to Mr. Chauncey Juday.

Lebertia parmata n. sp.

Pl. XXVII, Figs. 4, 5; Pl. XXVIII, Figs. 6, 7

This mite resembles *L. sparsicapillata* Thor closely, but is not identical with it, as has been determined by a comparison with a specimen of the European form sent to the author by Dr. Thor. The body is oblong, about 1.4 mm. in length. The color cannot be determined, as the material has been in preserving fluids. The group of epimera cover a relatively small part of the ventral surface. The cleft between the posterior ends of the second and third plates on each side is longer and wider than is common, and the space between the plates and the genital area is likewise greater. The posterior margin of the fourth epimera is narrow. The genital area is enclosed for only about two-thirds of its length by the approaching margins of the plates. The acetabula are of nearly equal size.

The epimera are covered with pores; the skin of the body at first appears smooth, but small pores and minute parallel striae can be made out by careful focusing. The large glands, of unknown function, described and figured by Thor (1902) for *L. porosa* were clearly seen close to the fourth epimera, with their long tubes extending to the capitulum (Pl. XXVII, Fig. 4).

The palpi have little to distinguish them from typical members. The last points of the legs are enlarged at the distal ends rather noticeably. There are stout bristles on all segments except the sixth, but no swimming hairs are present.

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Four specimens of this species were found in material taken by Mr. Juday from Kern Lake, California, July 20, 1904.

Lebertia artaacetabula n. sp.

Pl. XXVII, Figs. 1-3

This mite is a small member of the genus, only about 0.8 mm. in length. The nymph measures 0.65 mm. The color cannot be determined. But one adult has been found, together with tree nymphs. They were collected in the Waupaca Lakes, of Wisconsin, July 10, 1911. These are the only members of the genus found by the author in very extensive collections in that state extending over several years.

The epimeral shield covers the greater part of the ventral surface of the body, and extends back a little farther than the genital area. The genital plates are closely fitted into the bay thus formed by the epimera; they are distinctly narrowed at the anterior end. The chitenous bar at their posterior end is indistinct. The six acetabula are very narrow.

The skin appears to be very finely papilliated; the epimera and the appendages bear fine pores. The last three pairs of legs bear a few swimming hairs. On the joints of all of the middle segments of the legs the broad saber-like bristles are conspicuous, especially at the distal ends.

Lebertia porosa Thor.

Pl. XXVIII, Figs. 8-11

This species is represented here by one individual only. This was found in Twin Lakes, Colorado, in the weeds near shore, by Mr. Chauncey Juday, in August, 1902. It measures about 1.6 mm.; the color cannot be determined.

Dr. Thor has kindly sent the author several specimens of *L. porosa* from Europe. A careful comparison of the American form with these shows but slight differences, such as the little greater width of the fourth epimera, differences which do not appear to justify the formation of a new species, or even a variety, based upon a knowledge of but a single specimen.

The epimera cover a relatively larger area of the body than in *L. parmata,* and the posterior inner angle of the fourth is conspicuously broader. The genital plates come up close to the epimera

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and are enclosed by them for about three-fourths of their length. The last pair of acetabula are nearly circular. The skin is finely papilliate, with a few faint irregular lines. The appendages and plates have pores.

The second joint of the palpus is very stout and somewhat bent. The legs are rather slender, and there are not as many stout bristles on the joints as are found in the other two specimens here described. Swimming hairs, however, are found well developed on the fourth and fifth segment of the last two pairs of legs.

Biological Laboratory, Rockford College.

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EXPLANATION OF PLATES

Plate XXVII

Fig. 1. *Lebertia artaacetabula,* ventral view.
Fig. 2. *Lebertia artaacetabula,* palpus and legs, left side.
Fig. 3. *Lebertia artaacetabula,* nymph.
Fig. 4. *Lebertia parmata,* ventral view.
Fig. 5. *Lebertia parmata,* genital field.

Plate XXVIII

Fig. 6. *Lebertia parmata,* right palpus, inner side.
Fig. 7. *Lebertia parmata,* legs, right side.
Fig. 8. *Lebertia porosa,* epimera and genital area.
Fig. 9. *Lebertia porosa,* 1st leg.
Fig. 10. *Lebertia porosa,* 2nd, 3rd, 4th legs, right side.
Fig. 11. *Lebertia porosa,* right palpus, inner side.

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DEPARTMENT OF SUMMARIES

TO BE DEVOTED TO DIGESTS OF PROGRESS IN BIOLOGY

While the *Transactions* will continue to be primarily a Journal of research in micro-biology, it is recognized that the field has become so broad as to preclude the possibility of frequent articles in any one of the departments of special interest. Because of this it will be the policy to present, from time to time, supplementary digests of the progress being made in the various fields of micro-biology. It is also proposed to introduce similar summaries of the progress made in some departments not represented in our articles of research. This is done with the feeling that such reviews will increase the permanent value of the *Transactions* to all who may not have access to a large list of technical biological journals, nor the time to make the survey for themselves.

RESULTS OF RECENT STUDIES OF THE MAMMALIAN EPIPHYSIS CEREBRI

By H. E. Jordan

The last decade has witnessed great activity in the study of the "organs of internal secretion", notably the hypophysis. The definite results here obtained have stimulated renewed interest in that enigmatical body, the conarium or epiphysis cerebri. The investigation of this organ has been approached from various directions, namely, histological, histogenetic (embryological), pathological, clinical and experimental (physiological). In view of certain contradictory histological and experimental results, it seems premature to speak of a pineal "gland". Certain gross and microscopical morphological characters recall glandular tissue; but the absence of excretory ducts vitiates the strict analogy. Certain other characters (e. g. cysts or blind alveoli, profuse vascularity) suggests an organ of internal secretion. It is the main purpose of this paper to record, and briefly analyze, the findings which have been reported for and against physiological significance, and to determine the present state and general trend of our knowledge of the pineal organ of mammals. Certain details, of only subsidiary significance from the standpoint of our chief object, may properly be neglected. Nor need comparative morphological observations be here noted. As regards cytological and histological facts, only those will be specially considered that indicate or con-

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travert glandular activity. A summary of progress made will serve the better to indicate what still awaits solution, and, in a measure, suggest the best methods of further approach.

HISTOLOGICAL STUDIES

Since histological observations would seem to be simplest and therefore least liable to differences of interpretation, the analysis logically considers these first.

With modern technique Dimitrova[1] (1901) carefully studied the pineal bodies of a number of the common domestic mammals, and arrived at the conclusion that the parenchyma consists of a single cell type, a neuroglia cell. Cysts, pigment granules, brain sand, and a few striped muscle cells (ox) were also described in certain forms and in varying quantities. Certain cytoplasmic granules and vacuoles of uncertain significance, but suggestive of secretion, were also noted. The point of prime importance, however, pertains to the conclusion that the earlier[2] identification of several (two to four) different types of parenchymal cells is untenable. Nor could Dimitrova identify ganglion cells. On a basis of a histogenetic study of the pineal organ of the sheep, Jordan[3] (1911) confirms Dimitrova's findings respecting a single type of parenchymal cell. Costantini[4] (1910) on the contrary, describes "acidophile" and "basophile" cells, the presence of which he interprets as indicating an internal secretory function.

The neuroglia parenchymal cells frequently contain melanic granules (e. g. young sheep; Jordan[5]). Dimitrova[6], and Pappenheimer[7] (1910), moreover, describe colloid spherules in the cytoplasm. Such are certainly not present in sheep. In the latter, fat

1 Dimitrova, Z. (1901)—Recherches sur la structure de la glande pinèali chez quelques mammifères. Le Neuraxe 2:3.

2 The earlier histological literature is fully reviewed in the works of Studnicka (Oppel's Lehrbuch, 1905), Dimitrova, and Cutore; the pathological and clinical literature in the paper by Bailey and Jelliffe, loc. cit.

3 Jordan, H. E. (1911)—The Histogenesis of the Pineal Body of the Sheep. Amer. Journ. of Anat., 12:3.

4 Constantini, G. (1910)—Pathologica, 2:45. Ref. Neurol. Centrbl., Aug. 1, 1911.

5 loc. cit.

6 loc. cit.

7 Pappenheimer, A. M. (1910)—Ueber geschwülste des Corpus pineale. Virchow's Archiv für path. Anat. und Phys., Bd. 200.

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vacuoles frequently appear. Bailey and Jelliffe[8] (1911) state that "histologic evidence points to the fact that this structure (pineal body) contains elements which ally it to the blood glands—the chromaffine system—and that like other members of this series, the hypophysis, thymus, thyroid, and adrenals, etc., it plays a part in trophism". But a careful search for phaeochrome granules in the pineal body of the sheep gave me only negative evidence. Though the pineal is by some included in the "chromaffine system", I know of no positive cytological evidence of a "chromaffine reaction" of any parenchymal cells, hence its classification as a "blood-gland" (von Cyon[9]; 1910) seems unwarranted.

The sparse sensory nerve supply is limited to the proximo-ventral and proximo-dorsal portion of the structure; and the sympathetic to the blood vessels. The proximo-dorsal bundle from the superior commissure, may represent the parietal (pineal) nerve of lower forms. The body is very vascular. It is roughly divided by pial trabeculae into lobes and lobules (follicles). Commonly, mammalian pineals contain ependyma-lined cysts, clumps of pigment, and brain sand (acervulus), all of which features vary greatly according to form, and more especially according to age. Cysts and intracellular pigment granules are more numerous in youth, clumps of intercellular pigments and brain sand in advanced age. Pigment in the adult pineal seems to be most abundant in the horse (Dimitrova[10]).

Histological marks in general indicate a progressive involution with age, beginning about the time of puberty—about seven years in man (Bailey and Jelliffe[11]); about 8 months in sheep (Jordan[12]). This histological involution is accompanied by decrease in size.

Illing[13] (1910) has described a few smooth muscle cells in the finer trabeculae (ox). Ganglion cells, and occasional striped muscle

8 Bailey, P. and Jelliffe, S. E. (1911)—Tumors of the Pineal Body. Archiv f. Int. Med. 8:6.

9 v. Cyon, E. (1910)—Die Gefässdrüsen als regulatorische Schutz organe des Zentral, nervensystems. Berlin.

10 loc. cit.

11 loc. cit.

12 loc. cit.

13 Illing, P. (1910)—Vergleichend Anatomische und Histologische Untersuchungen ueber die Epiphysis cerebri einiger Säuger. Inaug. Diss. Leipzig.

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cells (ox and calf; Nicholas[14], 1900, and Dimitrova[15]) are possibly to be interpreted as teratomatous in nature. The pineal body, in common with rudimentary structures, seems especially prone to teratomata. Possibly the various nuclear and cytoplasmic phenomena (e. g. basophile and acidophile granules, vacuoles, "colloid spherules," etc.), on the basis of which the parenchymal cells have been classified as of several distinct types, have only degenerative significance.

Judged from structural marks, the pineal body has small functional value, limited to late foetal or early post-natal (pre-pubertal) life.

In view of the fact that striped muscle is the only mesodermal element that has been described in the supposedly normal pineal parenchyma, and this only occasionally and in very small amount, it may possibly be that cells so interpreted are in reality enlarged fusiform or rectangular elements which, by reason of a regular arrangement of the cytoplasmic granules, simulate a striped muscle-cell appearance. Otherwise, if, and where, actually present, the pineal is probably teratomatous.

The cytoplasmic melanic granules of foetal and young stages (sheep) must probably be interpreted in terms of the phylogenetic history (regression) of the pineal organ. Tendency to pigment elaboration may be a survival of the ancestral condition when the pineal functioned as an "eye" (light perceptive). An alternative interpretation might regard the melanic granules as secretory products in a transient phase as a chromatic proteid (Dyson[16], 1911), the vacuoles representing the decomposition phases. The pigment clumps of old pineals probably signify degeneration products.

The cysts also may have only ancestral significance; for they are especially numerous and well developed in certain birds. Since they are in communiction during no portion of the developmental history of the pineal either with the surface or the recess, however, they are the more difficult of interpretation. Moreover, they

14 Nicolas, M. (1900)—Note sur la presence des fibres musculaires striees dans la glande pineale de quelques mammiferes. Compt. rend de la soc. de biol., Paris.

15 loc. cit.

16 Dyson, Z. (1911)—An Investigation on Cutaneous Pigmentation in Normal and Pathological Conditions. Journ. Path. and Bact. 15:3.

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seem filled with a very dilute fluid. Indeed, the cysts appear to have origin through the accumulation of fluid forcing the arrangement of the parenchymal cells for a time into alveoli-like structures. The fluid may possibly be lymph, which has escaped from the large perivascular lymph spaces.

PATHOLOGICAL STUDIES

All the more complete histological descriptions of pineal tumors identify several types of cells more or less distinct. In a large pineal tumor (ca. 3.5 cm. dia.), for which the term "neuroglia ependymale" is suggested, Pappenheimer[17] describes besides neuroglia cells, "neuroblast-like cells", "ependyma-like cells" and embryonal striped muscle cells. The latter are very few in number, and found only in several sections. The cytoplasm of the several cell types is said to be frequently vacuolated and to contain "colloid" spherules.

In a large tumor (1.5 in. dia.) replacing the pineal body, Bailey and Jelliffe[18] describe hair and cartilage. Teratomata of the pineal body are described also by Neumann[19] (1900), Marburg[20] (1909; mixed tumor), and Frankl-Hochwart[21] (1909). Other neoplastic growths, replacing the pineal, include epithelial carcinoma, neuroglioma, sarcoma, adenoma, choric-epithelioma, gliosarcoma, hemorrhagic angiosarcoma, glioma, and gliosarcoma[22]. The frequency of a pure or mixed gliomatous condition among pineal tumors is significant. Indeed, the adult pineal is normally essentially a mass of neuroglia cells, i.e., practically a small or potential glimoa. In view of the frequent presence of considerable quantities of pigment, coupled with the tendency to neoplastic alterations, the absence of melanotic tumors of the pineal seems remarkable.

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17 loc. cit.

18 loc. cit.

19 Neuman, P. (1900)—Ein neuer Fall von Teratom der Zirbeldrüse. Inag. Diss. Königsberg.

20. Marburg, O. (1909)—Zur Kenntnis der normalen und pathologischen Histologie der Zirbeldrüse, Die Adipositas cerebralis. Arb. a. d. Wiener Neurol. Institut, 17.

21. Frankl-Hochwart, L. (1909)—Ueber Diagnose der Zirbeldrüsentumoren. Deutsch. Ztschr. f. Nervenh., 37.

22. For review of these cases of pineal tumors and list of literature see Bailey and Jelliffe.

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EMBRYOLOGICAL STUDIES

The pineal body arises as an ependymal diverticulum from the roof of the diencephalon. In the sheep (Jordan[23]) of the 5 cm. stage of development the ependymal cells of this apically thickened pocket are actively proliferating and undergoing the early differentiation processes in the formation of neuroglia and inter-neuroglia (less differentiated neuroglia) cells. Both types (stages) contain abundant small spherical melanic granules. At half term (21 cm.) the body is filled with blind cysts, lined with tall columnar (ependymal) cells. The cysts in sections contain a coagulated fluid. They progressively disappear, only a few persisting to birth and occasionally after. Cutore[24] (1911) records histological observations on certain embryonic and foetal stages in ox and man. He also recognizes originally only neuroglia (differentiated from ependyma) cells; but he describes a secondary differentiation into cells with "epithelial character" and "lypmhatic elements."

Cytological findings in the sheep give no evidence of secretory function. Cutore, on the contrary, maintains that an organ of such complex structure, constituted of neuroglia, epithelial, and lymphatic tissue, with tubular cavities, pigment cells, calcareous concretions, and a rich blood supply is not in a condition of regression. He believes that these structural characteristics warrant attributing to it the significance of a glandular organ with an internal secretion. However, the evidence presented for internal secretion seems far from adequate to the demands of a demonstration.

CLINICAL STUDIES

A very interesting and suggestive feature of pineal investigation relates to the clinical symptoms accompanying a tumor condition of this organ. Frankl-Hochwart[25] (1909) first directed special attention to the possible influence of the pineal body in cases of young individuals who showed—besides the ordinary tumor symptoms and those accompanying diseases of the corpora quadrigemina—abnormal size, extraordinary hair growth, obesity, drowsi-

23. loc. cit.

24. Cutore, . (1911)—Il corpo pineale di alcuni mammiferi. Archivio Italiano di Anatomia e di Embryologia, 9: 3 and 4.

25. loc. cit.

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ness, premature genital and sexual development, and mental precocity. Marburg[26] (1908-1909) had previously called attention to a possible relation between pineal tumor (hypopinealismus) and adiposis, "adipositas cerebralis". Examination of the clinical histories of the cases mentioned at the close of a previous section, "Pathological Studies", shows that the symptoms accompanying disease of the pineal organ are adiposis, early sexual maturity, and cachexia.

Illustrative of typical cases of diseased pineal are two described by Pellizzi[27] (1910) under the title, "Makrogenistomia praecox": One, a child of 5 years, measured 127 cm. Already at the seventh month the abnormal development was evident. At 2 years his genetalia were like those of an adult, and erections and ejaculations, with spermatozoa, occurred. Profuse pubic hair and beard were present. Radiographs indicated an age of about 16 years. The jaws, however, were infantile in character. A second patient was similar to the above, with hydrocephalus; and idiotic. Analysis of cases with similar symptom-complex reported by previous observers, and checked at necropsy, leads Pellizzi[28] to the hypothesis that the syndrome present in his cases relates to changes in the pineal body. He gives also a critical differential diagnosis between the pineal syndrome and the symptom-complex of pituitary disturbance (dyspituitarism).

An interesting complication arises from the fact that disease of the hypophysis also causes adiposis. Why should a pineal tumor produce the identical result? A possible explanation is as follows: a pineal tumor may block the aqueduct of Sylvius, and thus produce internal hydrocephalus, with consequent pressure on, and atrophy of, the hypophsis. On the basis of the work notably of Paulesco[29] (1908) and of Cushing[30] (1909) it seems certain that hypopituitarism is associated with adiposis, genital atrophy and

26. loc. cit.

27. Pellizzi, G. B. (1910)—La sindrome "macrogenistomia praece." Riv. Ital. di Neuropatol., Psich. ed Eleccroterapia, 3:5—Ref. Neurol. Centrbl., Aug. 1, 1911.

28. loc. cit.

29. Paulesco, M. C. (1908)—L'Hypophyse du Cerveau, Vigot Frères, Paris.

30. Cushing, H. (1909)—Partial Hypophysectomy for Acromegaly, with Remarks on the Function of the Pituitary Body. Ann. of Surg., 1903.

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lack of sexual development; and that apituitarism is a concomitant of cachexia, usually leading to death. However, pineal tumors seem to cause also genital hypertrophy and sexual precocity, a condition associated likewise with hyperpituitarism. Thus a seemingly serious contradiction appears, which somewhat invalidates the explanation of symptoms associated with pineal tumor as an indirect effect on the hypophysis. Bailey and Jelliffe[31] suggest that "possibly here the type of tumor introduces new elements that must be reckoned with, and whereas adiposis may be a more general factor dependent on hypopinealism, or on hydrocephalus, the sexual precocity may be due to a specific type of tumor, namely to teratomata, or possibly also to adenomata" p. 859. They suggest still another possibility: "It may be that the precocious sexual development may be an early irritative sign of a purely nervous character acting through the pars nervosa sympathetic system, which is very rich, and that later increases in pressure brings about degeneration or atrophic phenomena. Further, Cushing's hypothesis which assumes that dyspituitarism results from lessened pituitary secretions in the cerebrospinal fluid, which results from pressure on the infundibulum, may be the explanation of these sexual changes". p. 859.

More specifically, Marburg[32] (1909) describes (a) universal adiposity as due to hyperpinealismus, (b) premature development of the genital organs or genital hypertrophy as due to hypopinealismus, and (c) cachexia as due to absence of pineal or apinealismus.

Kidd[33] (1910) points out that a and b are the exact reverse of hyperpituitarism and hypopituitarism. He suggests that there may be a "functional relationship between the pineal and the pituitary, the former's function waning as the latter's begins to wax". On this basis he explains the results of the hypophysectomy experiments on puppies by Crowe, Cushing and Homans[34] (1910), show-

31. loc. cit.

32. loc. cit.

33. Kidd, L. (1910)—Pineal Experimentation. British Medical Journal, Dec. 24, 1910.

34. Crowe, S. J., Cushing, H. and Homan, J. (1910)—Experimental Hypophysectomy. Johns Hopkins Bulletin 21:230.

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ing that puppies survived this operation much longer than adult dogs. He suggests that "the puppy's active pineal may secrete a substance that to some slight extent takes the place, physiologically, of his at present immature pituitary" p. 2003.

EXPERIMENTAL (PHYSIOLOGICAL) STUDIES

The experimental work has naturally occupied itself with injections of pineal extract, and with attempts to extirpate the organ.

Injections of pineal extract were first made by von Cyon[35] (1903 and 1907) with the result of no effect on blood pressure and of irregular alterations in the force and frequency of the heartbeat, chiefly slowing it. He believed this effect due to the salts of the calcareous concretions. He further regarded the pineal as an organ designed to regulate mechanically, by contraction and relaxation, the pressure of the cerebrospinal fluid in the brain ventricles and incidentally cerebral blood pressure. That the possible functional significance of pineal extract does not depend upon the presence of the salts (calcium carbonate and phosphate) of the conconcretions seems strongly indicated by the fact of their increase with age, concomitant with the appearance of cytological and histological degenerative alterations.

Dixon and Halliburton[36] (1909) prepared in four different ways extracts of the pineal organ of 125 adult sheep. Injections were made intravenously into anaesthetized cats. They record a slight transient fall of blood pressure. They conclude that their work throws no light on the possible physiological action of the pineal body in mammals.

Jordan and Eyster[37] (1911) performed similar experiments with sheeps' pineal extract on dog, cat, sheep and rabbit. They record a uniform result of a slight fall of blood pressure, slight improvement in the beat of the isolated cat's heart, transient diuresis, and a slight irregular respiratory effect.

The foregoing results are again, in part at least, the reverse

35. v. Cyon, E.—Zur physiologie der Zirbeldrüse. Archiv für die gesammte Physiologie, 1903, p. 98, and Comptes rendus de l'Académie des Sciences, 1907, 144, p. 868.

36. Dixon, W. E. and Halliburton, W. D.—Der Pinealkorper. Quar. Journ. of exp. physiol., 1909, II, p. 283.

37. Jordan, H. E. and Eyster, J. A. E. (1911)—The Physiological Action of Extracts of the Pineal Body. Amer. Journ. of Physiol. 29:11.

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of those obtained with extracts of the hypophysis (anterior portion of pituitary body) and again suggests a compensatory or antagonistic regulatory functional relationship. Kidd further suggests pineal feeding and transplantation experiments. Extracts should also be tried upon completely hypophysectomized puppies to determine whether this might operate to prolong life.

Cytological study of the sheep's pineal organ has convinced me[38] that any possible secretory activity is limited to the young animal, or possibly also to the foetus. Accordingly it follows, in my opinion, that experimental work with extracts should be confined to those from young material. Kidd[39] urges the same point, and suggests that the question be investigated with extracts of the pineal of newly-born or very young rabbits, kittens, puppies or guinea-pigs. The experiments, he suggests, should be performed on two series of animals, namely (1) very young ones, and (2) adults. "It is possible that in the case of the former a condition of experimental hyperpinealismus might be induced; in the case of adult animals there should be subsequent microscopical examination of their pituitary, thyroid, parathyroid, adrenals and genital glands." The last suggestion made in this quotation assumes a close relationship between the pineal and the organs of internal secretion, for which assumption there is no basis of convincing histological or experimental data.

The association of hypopinealism with sexual precocity (a symptom also of hyperpituitarism) may perhaps be explained on the basis of the absence of an inhibitory (on pituitary growth) secretion of the pineal; or possibly simply the absence of the ordinary pressure prevalent during normal concomitant pineal and pituitary development.

Extirpation experiments have thus far been successfully performed in numbers only on rabbits. Exner and Boese[40] (1910) operated on 95, of which 22 survived, but only 6 lived to sexual maturity. Loss of pineal in these six gave no evidence of any effect on development or the appearance of sexual maturity.

38. loc. cit.
39. loc. cit.
40. Exner and Boese (1910)—Ueber Expérimentelle Extirpation des Glandula Pinealis. Deut. Zeit. f. Chir. October.

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Sarteschi[41] (1910) studied the pineal in castrated animals (certain common mammals). He destroyed the organ by thermocautery. Castration showed no effect. Neither did the destruction by cautery give any noticeable effect. The pineal was removed in 11 rabbits. Only two survived the operation. The only result recorded is emaciation. One is suspicious, however, that this may have been a general post-operative condition rather than a specific effect of pineal absence.

Cats and dogs are impracticable for this operation due to the presence of an ossified tentorium, into a median notch of the lower border of which the pineal organ fits.

From every standpoint (except expense) the sheep (lamb) seems the most promising subject for this work. Numerous attempts have been made by several investigators to remove this body in the sheep but as yet without successful issue. As in cerebral surgery generally, profuse hemorrhage obscures the field and renders difficult the final step in the operation, i.e., clean and complete removal. This is a prohibitory detail, however, which it seems possible ultimately to circumvent.

Future attempts to elucidate the functional significance of the pineal body of mammals will find the most promising material in extracts, and extirpation experiments, of lambs. The influence of the extracts should be observed in young, old and hypophysectomized animals (sheep).

To date, a conservative estimate of all the evidence indicates very meagre, if any, functional activity, probably never essential to life. The practical absence of a pineal body in the opossum (Jordan[42], 1911), adds further support to this conclusion. Biedl[43] (1910), however, arrives at the conclusion that the pineal body is an organ of internal secretion with metabolic significance limited to the young. The clinical symptoms associated with pineal tumor are probably to be interpreted as symptoms of pressure on the corpora quadrigemina, or as due indirectly, through compression of

41. Sarteschi, U.—Richerche istologische sulla glandula pinealse. Folia Neuro Biologica 4:6. Ref. Neurol. Centrbl. Aug. 1, 19.

42. Jordan, H. E. (1911)—The microscopic anatomy of the epiphysis of the opossum. Anat. Rec., vol. 5, no. 7.

43. Biedl, A. (1910)—Innere Sekretion, Berlin.

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the aqueduct and consequent third ventricle hydrocephalus, to disturbance of the pituitary body. The slight disagreement regarding histological details probably finds its explanation in the fact that the pineal body, in common with rudimentary organs generally, is the seat of regressive changes, and of some degree of teratomatous alterations[44].

Anatomical Laboratory, University of Virginia.

44. Other recent papers not directly accessible dealing with the pineal organ are (a) Anglade et Ducos, 1908, Note préliminaire sur l'anatomie et la physiologie de la glande pinéale. Sociétè d'Anat. et de Physiol. de Bordeaux, Proces. Dec. 14. (b) Calasescu et Urechia, 1910, Les cellules acidophiles de glande pinéale, Compt. rend. Soc. Biol. T. 68.; (c) Krabbe—Sur la Glande Pinéale chez l'homme. Nouvelle Iconographic de la Salpêtriere, Paris, 24 Année, no. 4. July, August 1911, p. 257-272.

SUMMARIES IN MICRO-BIOLOGY

For some months the Secretary has been planning to secure for this Journal and its Department of Summaries, a series of papers from biologists dealing with the chief groups of microscopic plants and animals. It has not been the purpose to present a complete survey of any of the groups. The wish has been rather to bring together in one article a statement of the following things:—general biology, the method of finding, the methods of capture and of keeping alive and cultivating in the laboratory; how best to study; the general technic; the most accessible literature; and a brief outline of the classification, with keys for the identification of at least the more representative genera and species of the micro-organisms likely to be found by the beginning students in the United States.

It has been felt that the getting together of such data as this, while not a contribution to science, would be a contribution especially to isolated workers and to teachers and students in the high schools and smaller colleges.

A paper has already appeared treating the aquatic Oligochetes. The following is the second paper of the series. It is proposed to have such synopses from time to time until the more common American species of such groups as the following have been covered: The Blue-green Algae, Conjugating Algae, Diatoms, other Green Algae, Zygomycetes, Downy Mildews, Yeasts, Powdery Mildews, Hyphomycetes, Smuts, Rusts; Rhizopods, Infusoria, Turbeliaria, Bryozoa, Water Mites, Entomostraca, etc.—[Editor.]

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THE MELANCONIALES*

By C. W. Edgerton

The Melanconiales, one of the orders of the large group of fungi generally known as the *Fungi Imperfecti,* consists of more than forty genera and several hundred described species. These are microscopic forms and many of them are as yet but little known to science. The genera in this group, as well as in the other groups of the imperfect fungi, are generally spoken of as "form" genera because the species, for the most part, are but the conidial stages of some of the higher fungi such as the ascomycetes. As the perfect or sexual stages are either not known or but rarely seen, it is necessary to classify these forms by the stages that commonly develop. And this results in a classification which is strictly artificial, many forms which would be widely separated in a natural classification being placed side by side in the "form" genera.

This group of fungi is a very important one both from the economic and scientific standpoints, and doubtless will interest some. Our lack of knowledge of many of the forms, however, makes the presentation of the subject rather difficult and all that can be done is to briefly describe a few of the species that are common in this country and also note the various problems which make the group particularly interesting.

Collection of Material for Study

The majority of these fungi are parasitic on higher plants, producing leaf spots, lesions on the stems, or rots of the fruits.

*This article is written by request. It is not meant to be technical in any way, it being the desire of the author to treat the subject in such a way that it will interest the teachers and students of biology in some of these lower forms of plant life that are usually not known outside of the larger colleges and universities. Our knowledge of many of these forms is not very definite and it would be impossible at the present time to enumerate and describe all the forms that are known to occur in this country. In this article, an attempt has been made to describe the more important genera and also to describe briefly a few of the more common species. In the genera, Gloeosporium and Colletotrichum, more species have been enumerated than in the other genera, as more work has been done with these and our knowledge is more definite.

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Many of them are very common and it is not usually difficult to pick up some of them. The spots or lesions, however, are not usually distinct from those caused by other parasitic fungi and it is not always possible to be sure of one of them in the field, especially by a person who has not had much experience in collecting them. After a person becomes better acquainted with some of the different forms, he can often tell whether a fungus belongs to this group by means of a good hand lens, though he can not always be sure. For the beginner who wishes to become acquainted with this group, leaves showing dead areas or spots, stems with blackened or sunken lesions, and fruits or vegetables with spots or rots should be collected. These can be brought into the laboratory and studied.

Examination and Study of Material Collected

For the examination of the material, a good microscope with 2/3 and 1/6 objectives, a good hand razor, a few spear shaped needles, and a few moist chambers are necessary. Thin cross sections through the fruiting pustules should be made with the razor and these should be mounted in water and examined. With the low power objective, the characters of the fruiting pustule can be made out and one can readily tell whether the fungus belongs to the Melanconiales or some other order. For the study of the other characters such as the spores, coniliophores, and setae, the high power objective is necessary. A person who has studied the group for some time can generally tell whether a fungus belongs in this group or not by merely scraping off some of the pustules and examining them in a crushed mount. He is able to do this, however, because he knows the shape and appearance of the spores and setae. If there is anything peculiar in the mount, he must also make sections for examination.

These crushed mounts or sections can be preserved by running a little 50% glycerin tinted with eosin under the cover slips. These preserved mounts are often very useful for comparison when other forms are collected.

Often material that is brought in from the field shows the fungus only partially developed, or else the spores have all been washed off by recent rains. If the material is in this condition, it can be placed in a moist chamber for a day or so and examined again.

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Many of the forms will develop well in this manner. Often also the moist chamber comes in handy in preserving the material over night or even longer when an immediate examination is impossible.

If a thorough study is being made of any of these fungi, microtome sections are often not only helpful but essential. With these, the development of the pustules, the finer characters of the conidiophores and underlying stroma, and the condition of the diseased host cells can be made out. For a killing solution, the writer generally uses Gilson's Fixing Solution*. This is an alcoholic solution and the spores are held in place in the pustules. With the aqueous fixing solutions, the spores are generally washed out of the pustules. Any of the ordinary stains can be used, the writer generally using Iron Alum Haematoxylin with Congo Red as a counter stain.

Culture of the Fungi

A great deal can be found out concerning these fungi by merely examining the material collected in the field, but if this can be supplemented with some culture work, the study will become more interesting and instructive. If some of the apparatus and materials of the bacteriological laboratory are available, such as sterilizers, petri dishes and test tubes, the fungi should be cultured and their growth watched. Most of the fungi grow well on any of the ordinary culture media, though media made from potato tubers, bean pods, or corn meal are perhaps the best. These forms can be isolated by either making dilution cultures with the spores, or by transferring some diseased material from the host plant after the outside tissues are stripped off or cut away with a sterile knife. A large majority of these fungi grow and fruit well on culture media.

The Orders of the Imperfect Fungi

In the classification of most plants, whether high or low in the plant kingdom, the characters of the sexual stage are generally used, but in the *Fungi Imperfecti,* the sexual stages are so often unknown or so infrequently seen, that other characters must be used. As the conidial stage of these forms is the one most often

*Gilson's fixing solution: 95% alcohol 42cc., water 60cc., glacial acetic acid 18cc., nitric acid (conc) 2cc., corrosive sublimate (sat. sol.) 11cc. The material is left in the fixer 6-24 hours and washed directly in 70% alcohol.

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seen, the characters of this stage are the ones which must be used if the fungi are to be satisfactorily separated and classified.

The *Fungi Imperfecti* are divided into three orders, the characters of the conidial fructifications being the ones that are used to separate them. These orders are as follows:

Sphaeropsidales. In this order, the conidia are borne on simple or branched conidiophores within pycnidia or within cavities in a stroma. The pycnidia are quite variable in shape, size, texture, and color, and they may be open to the surface by an ostiole or they may be entirely closed.

Melanconiales. In this order, the spores are borne on short, simple or branched conidiophores which arise from a more or less well developed stroma. The fruiting pustule, or acervulus, consisting of the stroma, conidiophores, and spores, usually develops underneath the spidermis or cortex of the host plant and later breaks through to the surface, though this is not always the case.

Hyphomycetes. In this group, the conidia are borne in various ways, but generally on conidiophores arising directly from the mycelial threads. This group includes all of the forms that cannot be classified in the first two orders.

The Acervulus

As can be seen, the presence of the acervulus is the one distinguishing character of the Melanconiales. Beyond this one character, there is nothing common in the group. And as the acervulus is not a definite structure, it is not always a good separating character. Forms exist which are more or less on the boundary line between the Melanconiales and the Sphaeropsidales, and also between the Melanconiales and the Hyphomycetes. Furthermore there are forms which could be placed in two of the orders and some in even all three, as different methods of spore development occur at different times in their development.

The shape and appearance of the acervulus varies considerably even within the same species. Figures 1 and 2 represent two types which often occur. Figure 1 was drawn from sections from a tomato that was affected with a Gloeosporium, while figure 2 was from an apple also affected with a Gloeosporium. This difference, however, is not a specific one as both types frequently develop on

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the same host. Figure 2, as a rule, represents an older condition than figure 1. These figures show the main characteristics of the

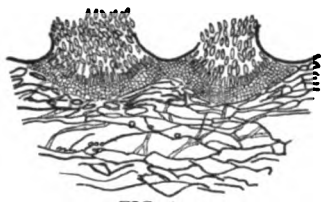

FIG. 1

FIG. 2

Fig. 1. Acervulus of *Gloeosporium fructigenum* from the fruit of tomato
Fig. 2. Acervulus of *Gloeosporium fructigenum* from apple.

acervulus of any of the genera, showing the ruptured epidermis, the fungus stroma at the base of the acervulus and the conidiophores and spores.

While all of the members of the Melanconiales develop the spores in acervuli, this does not mean that they are related. There are many forms possessing this structure which are known to be widely separated and would be placed in widely separated groups if a natural classification were used. Many have looked on it as peculiar that these divergent forms would have the same method of conidial formation. But when we study the development of the acervulus and understand its probable origin, it does not seem so peculiar. It is certain that these fungi did not all originate from a common form and it must follow that this method of fruiting must have been developed by a number of different forms independently.

All of these fungi which grow within the tissues of higher plants, must be able in some way to come to the surface for spore formation. The single mycelial threads of most of them are unable to rupture the epidermis of the host plant and some other method must be used. In the Melanconiales, a number of fungus threads develop underneath the epidermis, form a fungus stroma, and begin to produce a dense layer of short conidiophores. While a single fungus thread can not develop a great deal of strength by itself, this whole mass of fungus tissue by an outward growth, can exert enough strength to rupture the epidermal or cortical tissue and thus come to the surface for spore formation. There is no great regularity about these acervuli in shape and size or in the amount of stromatic tissue developed; in fact an acervulus is really nothing

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but a rather dense mass of fungus tissue and not a definite fruiting body as this term is applied to other forms of fructification. Knowing the structure and development of the acervulus, it is then not difficult to understand why so many different forms have this method of spore production. This form of fruiting is very simple, and perhaps is the easiest method which could be developed by the forms which grow within the tissues of living plants. The mere fact that many of these forms will grow like hyphomycetes producing the spores directly on the mycelium when there is sufficient moisture to allow them to grow on the surface of the culture medium or affected plant, shows that the acervulus is not always a definite structure but rather a development of tissue to bring the fungus to the surface.

The Perfect Stages

A number of species of the Melanconiales have been shown in recent years to have ascogenous stages in their life history. Strictly speaking, these forms should not be considered as members of this order and should be classified among the ascomycetes, but for the sake of convenience, they are still often considered as members of this group. The perfect stages are only rarely seen, and if an attempt is made to determine a species, it must be done with the imperfect characters alone.

Some of our most important and common forms of this order are now known to have ascogenous stages. In some of these, the ascomycete fructification develops as a winter stage, that is, it develops on the dead portions of the host plant during the winter months. Examples of such forms are the Gloeosporiums from the sycamore and currant, the Marssonia from the walnut, and the Myxosporium from the dogwood. In other forms, the season seems to have nothing to do with the development of the ascogenous stage, this being developed along with the conidial or immediately following it. This group includes many of our common Gloeosporiums and Colletotrichums such as are found on apples, cotton bolls, etc.

Many different ascogenous genera have been connected with different members of the Melanconiales, and many of these are

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widely separated in our present classification of the ascomycetes. Among these are the following:

Gnomonia, connected with forms in the genera Gloeosporium and Marssonia.

Glomerella (figure 3), connected with forms in the genera Gloeosporium and Colletotrichum.

Pseudopeziza, connected with a Gloeosporium.

Neofabrea, connected with a Gloeosporium.

Sphaerella, connected with a Gloeosporium.

Diaporthe, connected with forms in the genus Myxosporium.

FIG. 3

Fig. 3. *Glomerella gossypii*, the perfect stage of *Colletotrichum gossypii*.

Many other ascogenous forms have also been found growing with members of the Melanconiales, and the probability is that they are connected, though the absolute proof is still wanting. Among these are the following:

Trochila, with forms in the genera Gloeosporium and Marssonia.

Anthostomella, with Myxosporium species.

Pseudovalsa, with Coryneum species.

While there are doubtless other ascogenous genera connected with forms in the Melanconiales, these are sufficient to show that this group is made up of a large number of widely related forms, and that the classification does not show relationship among them.

Characters of the Genera

According to Engler and Prantl, there are forty-six genera in the order Melanconiales. These are separated mostly on spore characters, though other characters such as the presence or absence of setae, or the presence or lack of branching of the conidiophores are sometimes used. A great number of these genera, however, are

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not important. Many of them have only from one to a few species and these are very rare. Many of them are also but very little known. There are only about eight genera that are really important and common and these only will be considered in this article. A key for distinguishing these genera follows:

I. Conidia hyaline, one-celled, globose to oblong.
  1. Fungi generally growing on leaves, fruits or tender stems.
    (1). Acervuli with but few or no setae.....Gloeosporium.
    (2). Acervuli with setae, generally abundant..Colletotrichum.
  2. Fungi generally growing on woody branches or trees or shrubs.
    (1). Spores straight or slightly curved.....Myxosporum.
II. Conidia dark, one-celled, globose or oblong, solitary on the conidiophores ..... Melanconium.
III. Conidia hyaline, two-celled, fungus growing on leaves.....Marssonia.
IV. Conidia dark, two to several septate, oblong to cylindric.
  1. Condia with cilia or appendages at the apex.....Pestalozzia.
  2. Conidia without cilia, oblong or elongate.....Coryneum.
V. Conidia hyaline, long filiform, generally continuous....Cylindrosporium.

As may be seen from the key, the characters separating some of the genera are not clear cut and distinct. The differences between Gloeosporium and Colletotrichum, or Gloeosporium and Myxosporium are not always clear. In fact, some individual species may be placed in any one of the three genera. However, as most of these forms will finally be placed in the genera of ascomycetes to which they really belong, their position among the imperfect fungi is not really important.

Specific Differences

Before taking up the common species of the Melanconiales, it may be well to call attention to some of the difficulties ahead of the person who tries to determine these forms accurately. Up until the past few years, botanists as a rule determined the species in this group to a large extent by the hosts upon which they were found growing. If a form was found on a new host, it was usually determined as a new species. While some of these forms possess morphological characters that distinguish them from other species, we have a large number of others which cannot be told apart by morphological characters. During the past few years, a number of botanists have been working on this group and it has been found that a number of these described forms are identical. This has

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been proven by cross inoculation experiments. It has also been found that some forms, though morphologically very similar to others, cannot be successfully inoculated into the hosts of the other forms. This makes them distinct from a physiological standpoint at least. Whether these should be considered as good species is still an undecided question. In this article, these forms are left as distinct species and they are separated from each other by host characters alone.

Furthermore, a person is liable to pick up forms, especially from the genera Gloeosporium and Colletotrichum, which do not seem to be described, or at least are not described from the host on which he found them. It is difficult to determine these beyond the genus and it is perhaps better not to try to determine the species, as it is almost impossible to make sure of their identity without carrying on cross inoculation experiments.

In this article, only the common and better known forms are included. It is possible that all of these are not good species, but it seems better to keep them separate until they are proved to be identical with other forms.

THE GENUS GLOEOSPORIUM

The genus Gloeosporium, with some 400 described species, is the largest one of the order, and contains many forms which are very common. Some of our worst diseases of plants are produced by members of this genus, the loss produced by them running up into millions of dollars each year.

In this genus, the acervuli generally develop underneath the epidermis or cortex of leaves, stems, or fruits and become erumpent. The spores are hyaline and either straight or curved. They are typically one-celled, though some two-celled spores are met with in some of the forms. The conidiophores are short and much crowded. A few setae are sometimes present, though usually not abundant.

There are a number of very common forms and a large number which are not well known. Besides the described forms there are a large number of others on various hosts, some of which are distinct enough to be good species. The forms commonly met with in this country follow:

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Key to the Species of the Genus Gloeosporium

I. Spores straight or nearly so, oblong or cylindrical.
  1. Spores relatively large, usually more than 10μ in length.
    (1). Spores exuding from the acervuli in slimy pink masses.
      a. Found on apple, pear, quince, grapes, fig, tomato, pepper, sweet pea, maple leaves, raspberry canes, and perhaps other fruits and stems. *G. fructigenum.*
      b. Found on greenhouse plants, very close to the preceding species and perhaps identical...*G. cinctum.*
      c. Found on privet, very close to preceding species. ..... *G. cingulatum.*
    (2). Spores in mass some other color than pink.
      a. Found on sycamore and oaks; ascogenous stage, Gnomonia.....*G. nervisequum.*
  2. Spores smaller, generally less than 10μ long.
    (1). Found on blackberry and raspberry canes....*G. venetum.*
    (2). Found on fruit and branches of grape..*G. ampelophagum.*
    (3). Found on cranberry fruit.....*G. minus.*

II. Spores more or less curved.
  1. Found on clover and alfalfa; spores fusoid.....*G. caulivorum.*
  2. Found on currant leaves; spores sickle shaped; ascogenous stage, Pseudopeziza.....*G. ribis.*
  3. Found on branches and fruits of apple in the northwest; spores decidedly curved; ascogenous stage, Neofabrea. .....*G. malicorticis.*
  4. Found on cactus in the southwest; spores lunate; ascogenous stage, Sphaerella.....*G. lunatum.*

Description of Common Species

Gloeosporium fructigenum Berk. This fungus is quite common on a large number of hosts though perhaps more frequently seen on the apple. The loss caused by this fungus is very great. The fungus attacks the fruits, branches and leaves of the different hosts. Affected fruits show spots or a general decay; affected stems, cankers or lesions; and affected leaves, either spots or a general blight. The acervuli develop as little papillae over the surface of the diseased portion of the host plant. The spores are produced very abundantly and ooze out of the acervuli in slimy pink masses. They are oblong to cylindric, often slightly narrower near the center than towards the ends, hyaline, one-celled, and about 12-20 x 4-6μ in size. When fresh, a clear nucleus is generally seen near the center of the spore. A few scattering setae are also some-

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times present in the acervuli. The ascogenous or perithecial stage develops occasionally along with the conidial stage on the host or immediately following it, and it develops quite commonly on artificial media in pure cultures. The ascospores are generally slightly curved but in other ways they are very similar to the conidia. Since the discovery of the perfect stage, the fungus has gone by the name of *Glomerella fructigena* or *Glomerella rufomaculans*; the former name being the correct one according to our present rules of nomenclature.

Gloeosporium cinctum B. & C. This fungus is found on orchids and other plants commonly grown in greenhouses. The morphological characters are practically identical with the preceding species and it is possible that the two are the same. However, not enough cross inoculation experiments have been carried on to make perfectly sure of their identity and it seems better to leave them separated. The ascogenous stage is often seen and is now known as *Glomerella cincta* (Stoneman) Sp. & v. Schr.

Gloeosporium cingulatum Atk. This fungus grows on the smaller branches of privet, causing them to die and blight. The characters of the conidial and ascogenous stages are practically identical with *Gloeosporium fructigenum*. Since the discovery of the ascogenous stage, the fungus has been known as *Glomerella cingulata* (Stoneman) Sp. & v. Schr.

Gloeosporium nervisequum (Fuckel) Sacc. This species is quite common on sycamore and oaks of the species, *alba, velutina,* and *coccinea*. On these trees, it occurs both on the twigs and leaves. On sycamore leaves, it first attacks the tissue along the veins, causing it to turn brown and die. It was from these dead strips along the veins that it received its name. It also affects the young twigs and kills them, causing the leaves to wilt and die. The oak leaves, as a rule, are affected in spots, though occasionally the disease runs along the veins. In all of the affected tissue, the acervuli develop abundantly. The acervuli are light in color and from 100-300μ in diameter. The conidia, which are about 10-14 x 4-6μ in size, develop in abundance on the conidiophores and in moist weather or when the leaves are placed in moist chamber ooze out of the acervuli in creamy white masses or strings. On the twigs, the acervuli

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develop in a similar manner to those on the leaves. This stage on the twigs, if it were the only one known, would place the fungus in the genus Myxosporium, where it has been described as *Myxosporium valsoideum* (Sacc.) All., and *Myxosporium platanicolum* E. & E. The ascogenous stage which develops on the old leaves on the ground during the winter months, is known as *Gnomonia veneta* (Sacc. & Speg.) Kleb. The characters of this stage are very different from those of Glomerella, the ascospores being two-celled, with one of the cells several times as large as the other.

Gloeosporium venetum Speg. This fungus occurs on the leaves and canes of blackberries and raspberries and is quite common in the northern states where it often does considerable damage. The disease appears in the form of spots on the canes, these at first being purplish in color but later become grey and sunken. On the leaves, small dead spots develop. The acervuli, which form quite abundantly in the older spots, are small, averaging about 50-150μ in diameter. The spores are hyaline, one-celled, and small, generally only about 6-8μ long. The fungus grows very poorly on artificial media and is not always easy to isolate. The 4-7 x 3-4μ. The ascogenous stage is not known.

Gloeosporium ampelophagum (Pass.) Sacc. This fungus occurs on the fruit and twigs of the grape and is well distributed throughout the United States. On the fruit, sunken spots develop which have more or less of a bird's eye appearance. The central paler portion of the spot is surrounded by a reddish zone which is generally quite characteristic. On the twigs, the spots are similar to those on the fruit, except that they are elongated in the direction of the main axis of the twig. The acervuli develop quite abundantly over the surface of the spots. The spores are hyaline, generally elliptical to oblong in shape, and small, usually about 4-7 X 3-4μ. The ascogenous stage is not known.

Gloeosporium minus Shear. The fungus occurs sparingly on the leaves and fruit of the cranberry. Definite spots are not formed, though the tissue is slightly brown around the acervuli. The acervuli are small and scattering. The conidia, which are about 6-9 X 3-4μ in size, form in a pale pinkish glutinous mass at the top of the acervulus. No ascogenous stage is known.

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Gloeosporium caulivorum Kirchner. This fungus is quite abundant on clover in certain sections of the United States, especially in the West Virginia-Pennsylvania region. Long, dark colored, sunken spots develop on the stems and petioles of the host, these often causing the death of the portions of the plant above. The small acervuli develop abundantly in the sunken spots. The conidia are hyaline, cylindrical to fusoid, curved, and 12-22 x 3.5-5.5μ in size. No ascogenous stage is known.

Gloeosporium ribis (Lib.) Mont. & Desm. This fungus occurs quite abundantly on leaves of the cultivated currant in various parts of the United States and often does considerable damage by defoliating the plants. The dead spots which develop on the leaves are brownish to blackish with a somewhat lighter center and are generally about 1-2 mm. in diameter. The acervuli develop on the upper side of the leaf. The spores (Figure 4) are hyaline, one-

FIG. 4

Fig. 4. Spores of *Gloeosporium ribis*

celled, sickle-shaped, and are about 15-20 x 6-8μ in size. They ooze out of the acervuli in small light colored masses. The ascogenous stage has been found and is now known as *Pseudopeziza ribis* Kleb.

Gloeosporium malicorticis Cordley. This species occuring on fruit and branches of the apple in the north Pacific states, often does considerable damage, causing perhaps the worst disease of apples in that section. On the branches and twigs, the disease does the most damage as it causes the formation of large cankers followed by the death of the portions of the host above the parts affected. The cankers are slightly darker in color than the healthy portions and somewhat sunken. On the fruit, the fungus causes the development of light brown rotten spots which may gradually spread over the whole surface. On both the wood and the fruit, the acervuli develop and produce spores in abundance. The spores are very striking in appearance on account of their shape. Some of them are bent into nearly a complete circle. The ascogenous

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stage has been found and described as *Neofabrea malicorticis* Jackson.

Gloeosporium lunatum E. & E. This species occurs abundantly on certain species of cactus in the southwest, forming circular spots 1-3 cm. in diameter. The acervuli are abundant, 60-125μ in diameter. The conidia are lunate fusoid, 12-20 x 2-3μ, often one septate. This species is not a typical Gloeosporium on account of the spores being often septate. Possibly the genus Marssonia would fit it better than Gloeosporium. However, the ascogenous stage has been found, and the genus to which the conidial stage belongs is not really important. The ascogenous stage has been described as *Sphaerella opuntiae* E. & E.

THE GENUS COLLETOTRICHUM

The genus Colletotrichum, with some 80 or more described species, is very similar to Gloeosporium. The only difference between the two genera is in the abundance of setae in the acervuli. The species in this genus seem to fall into groups; those with straight spores and those with curved spores. Many of the straight spored forms are very closely related to *Gloeosporium fructigenum,* perhaps some of them being identical. The forms with curved spores, however, are very distinct. This genus also contains some very bad disease producers, nearly all of those described below causing serious trouble. Mention will only be made of the more common described forms, and these will be separated by the hosts upon which they are found growing, as it is impossible to separate them by morphological characters.

Key to the Commoner Species of Colletotrichum

I. Spores straight or nearly so.
   1. Found on cotton in southern states.....*C. gossypii.*
   2. Found on watermelon and cucumber.....*C. lagenarium.*
   3. Found on bean.....*C. lindemuthianum.*
   4. Found on clover and alfalfa.....*C. trifolii.*
   5. Found on snapdragon.....*C. antirrhini.*
   6. Found on citrus fruits.....*C. gloeosporioides.*

II. Spores curved.
   1. Found on sugar cane.....*C. falcatum.*
   2. Found on Johnson Grass, sorghum, and related plants..*C. lineola.*
   3. Found on grasses and cereals.....*C. cereale.*

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Description of Common Species

Colletotrichum gossypii Southworth. This species is found on the various parts of the cotton plant, though it is seen more frequently on the bolls. It at first produces sunken discolored spots on the bolls, but these generally increase in size so that a general rot is produced. The spores are produced very abundantly in the acervuli, often the whole surface of the spot being covered with a slimy pink mass of them. The spores (Figure 5) which are identical with those of *Gloeosporium fructigenum,* develop both on the

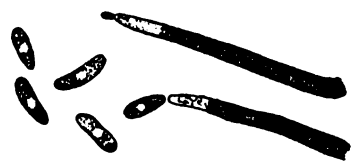

FIG. 5

Fig. 5. Spores and setae of *Colletotrichum gossypii*

conidiophores and setae. The setae are usually abundant. The ascogenous stage has been found and is now known as *Glomerella gossypii* Edg.

Colletotrichum lagenarium (Pass.) Ell. & Hals. This fungus is found on the fruits and leaves of such plants as cucumbers and watermelons. Watersoaked, sunken spots which later become covered with the slimy spore masses, form on the fruits and often ruin them. The morphological characters of this fungus are practically the same as those of *Gloeosporium fructigenum.* No ascogenous stage has as yet been found.

Colletotrichum lindemuthianum (Sacc. & Magn.) Scrib. This fungus, found on the pods and leaves of the cultivated bean, causes the much dreaded bean anthracnose disease. Large, sunken, dark colored, slimy ulcers develop on the bean pods rendering them worthless. Morphological characters of the fungus quite similar to *Gloeosporium fructigenum,* the main difference being the darker color of the bean fungus. Physiologically, however, this fungus is quite distinct. The ascogenous stage, belonging to the genus Glomerella, has been found in pure cultures but it has not been named.

Colletotrichum trifolii Bain. This fungus forms dark colored spots on the stems and petioles of clover and alfalfa, often doing a

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great deal of damage. Morphological characters similar to *Gloeosporium fructigenum*. The ascogenous stage has been reported but has not been described or named but probably belongs to the genus Glomerella.

Colletotrichum antirrhini Stewart. This fungus occurs on the cultivated snapdragon and some related wild plants producing dark colored lesions on the stems and petioles. Morphological characters similar to *Gloeosporium fructigenum*. The ascogenous stage has as yet not been found.

Colletotrichum gloeosporioides Penz. This fungus, found on various citrus fruits such as oranges, lemons, and pomelos, produces a disease of the fruits, leaves, and twigs. Spots are formed on the fruits which are often followed by a general rot. The leaves are either affected in spots or along the margins. The twigs are also killed back from the tips. The morphological characters of the fungus are similar to those of *Gloeosporium fructigenum*. No ascogenous stage has been reported.

Colletotrichum falcatum Went. This fungus is found on the leaves and stalks of sugar cane in the southern states, where it often does considerable damage. Spots up to one to two feet long develop on the midribs of the leaves. These spots are at first red in color but later turn to white or gray at the center. The fungus also grows on the inside of the cane stalk. The tissue is at first turned red but later horizontal white spots appear within the red. The fungus fruits abundantly on the older spots on the leaves and occasionally on the stalks. To the naked eye, the acervuli appear as small black pustules. The acervuli always contain setae in abund-

FIG. 6

Fig. 6. Spores of *Colletotrichum falcatum*

ance. The spores (Figure 6) are hyaline, curved, somewhat pointed at one end and more rounded at the other, 24-32 x 6-7μ. The spores when fresh show a clear nucleus near the center. No ascogenous stage has been found.

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Colletotrichum lineola Corda. This fungus is found on the leaves and to some extent on the seeds of such plants as Johnson grass, broom corn and sorghum. Bright red spots develop very abundantly on the leaves, these being covered with the black acervuli. Morphological characters are very similar to those of *Colletetrichum falcatum,* though this fungus cannot be satisfactorily inoculated into sugar cane. No ascogenous stage has been found ious cereals and grasses in various sections of the United States as yet.

Colletotrichum cereale Manns. This fungus is found on var- affecting various parts of the host plants, though perhaps more common in the flowering parts. It often causes a shrinkage and shriveling of the grains. The morphological characters of the fungus are very similar to those of *Colletotrichum falcatum,* though the fungus is probably physiologically distinct. No ascogenous stage has as yet been found.

THE GENUS MYXOSPORIUM

The genus Myxosporium, with about 90 described species, contains a few species that are fairly common in the United States. The characters distinguishing this genus from Gloeosporium are not always clear cut. The Myxosporium species generally grow on woody branches, while the Gloeosporium species on fruits, leaves, and tender branches. But there are a number of species which grow on both woody branches and fruits, such as *Gloeosporium fructigenum* and *Gloeosporium malicorticis.* It seems best to restrict the genus Myxosporium to those forms that grow only on woody branches. Some of the species of Myxosporium are parasitic while others are only saprophytic.

In the genus Myxosporium, the acervulus usually develops underneath from one to several layers of cells of the host plant and then becomes erumpent. The conidia, which are one-celled, hyaline, and straight or slightly curved, are produced singly on the short, simple crowded conidiophores. There are a few well known species and many that are but little known. As only a few of these forms will be mentioned, no attempt will be made to separate them by a key.

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Description of Species

Myxosporium corticolum Edg. This fungus occurs very abundantly on branches and trunks of apples and pears in the northeastern states. It is principally a disease of the bark tissue and does not extend to the cambium. Slightly sunken cankers are formed which are at first smooth but later become cracked and checked. The acervuli, which are about 1-2 mm. in diameter, develop under four or five layers of bark cells. The spores are straight, cylindrical, hyaline, 18-32 x 6-9μ. These ooze out of the acervuli in white strings or masses.

Myxosporium coloratum (Peck) Sacc. This fungus is found is found on the branches of the yellow poplar (Liriodendron). It is a very striking species as the spores ooze out of the acervuli in reddish masses. The acervuli are small and appear as little papillae over the surface of the bark. The spores are hyaline, straight or curved, 12-18 x 5-8μ.

Myxosporium nitidum B. & C. This fungus is found on the branches of dogwood (*Cornus alternifolia*) and is very common in the northeastern states. The acervuli are small, about 40-60μ, but abundant on the dead portions of the host, appearing as small yellow papillae. They develop under several layers of the host cells. The spores, which are hyaline, straight, 9-12 x 3-5μ, are produced very abundantly and ooze out in yellow masses. The ascogenous fungus *Diaporthe albocarnis* E. & E. appears on the diseased twigs in the late winter and, as has been proven by some cultural experiments, belongs to the Myxosporium.

Myxosporium ulmi (Oud.) Sacc. This fungus is occasionally found on the dead branches of the elm. The acervuli appear as little papillae over the surface of the bark. The conidia are hyaline, oval or obovate, 14-19 x 6-8μ.

THE GENUS MELANCONIUM

The genus Melanconium, consisting of over 100 described species contains a few common well known species, but most of them have been but little studied. The characters of this genus approach quite closely to those of the genus Gloeosporium with the exception of the color of the spores. While Gloeosporium spores are hyaline, Melanconium spores are dark colored. Setae are also

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lacking, and the spores are typically straight. Only two species will be mentioned in this discussion. While there are a number of others described from woody branches of trees and shrubs in the United States, these are mostly uncommon or but little known.

Description of Species

Melanconium fuligineum (Scribn. & Viala) Cav. This fungus occurs on the fruit and perhaps the leaves of the cultivated grape, especially in the southern states. The fruit rots and dries up on the vines. The acervuli appear as small papillae over the fruit. The spores are slightly smoky in appearance, elliptical to oblong, 8-12 x 3.5-5μ. There seems to be some confusion regarding this fungus and *Gloeosporium fructigenum* on account of some similarity between the two. The spores of the Melanconium, however, are smaller and generally more pointed than those of the Gloeosporium and when mature show the smoky appearance.

Melanconium sacchari Massee. This fungus is found on dead pieces of sugar cane, and also occasionally on the living cane, in the Southern states. It produces the well known "Rind Disease" which is very serious in some places in the tropics. Sugar cane stalks affected with this fungus dry out rapidly, and the rather large black acervuli develop very abundantly on the rind tissue especially around the nodes. The spores (Figure 7) are dark brown, oval to

FIG. 7

Fig. 7. Spores of *Melanconium sacchari*

cylindrical, often guttulate, 10-12 x 4-6μ. The spores ooze out of the acervuli in black glistening masses or in long black strings, these sometimes being several centimeters long.

THE GENUS MARSSONIA

The genus Marssonia consists of about 80 described species, some of which are very common and well known. Most of the species in this genus are parasitic on leaves. This genus is in many ways very similar to Gloeosporium, the only real difference is that the spores are two-celled instead of continuous. The spores are

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hyaline, stright or curved, and are borne on short crowded conidiophores in the acervulus. The different described species have never been worked over carefully, so only a few of the better known ones will be mentioned in this article.

Description of Species

Marssonia castagnei (Desm. and Mont.) Sacc. This fungus occurs very commonly on the leaves of the white poplar in the United States. The leaves are sometimes affected so seriously that many of them are shed. The spots formed, are somewhat circular and dark colored. A few small acervuli develop near the center of each spot, the spores oozing out of them in more or less whitish masses. The conidia (Figure 8) are hyaline, oblong clavate, slightly

FIG. 8

Fig. 8. Spores of *Marssonia castagnei*

constricted at the septum, 18-25 x 8-10μ. The ascogenous fungus, *Trochila populorum* Desm., is often found during the late winter in the old spots on the leaves and is probably the perfect stage of this Marssonia.

Marssonia juglandis (Lib.) Sacc. This fungus forms small circular or irregular spots on the leaves of walnut and butternut and is quite widely distributed throughout the United States. The conidia are fusoid, curved, with the apex somewhat pointed, 20-25 x 5μ. The ascogenous stage has been found and is known as *Gnomonia leptostyla* (Fr.) Ces. and De Not.

Marssonia martini Sacc. and Ellis. This fungus forms small circular spots on the leaves of some species of oaks. The acervuli develop abundantly near the center of the spots. The spores are fusoid, 12-15 x 2.5μ.

Marssonia ochroleuca B. & C. This fungus forms small circular spots on the leaves of the chestnut. This fungus is very similar to the preceding species.

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THE GENUS PESTALOZZIA.

The genus Pestalozzia is a very large one, having over 200 described species. The forms of this genus are very common, though our knowledge of them is so slight that they are difficult to determine. Some of them are parasitic, but a great many are saphrophytic and are probably not confined to any one host. The acervuli have the same general structure as those of the previous genera. The spores (Figure 9) however, are very characteristic.

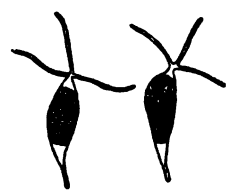

FIG. 9

Fig. 9. Spores of a Pestalozzia from a Leaf Spot on Sugar Cane

They are two to several septate and at least some of the cells are dark colored. Furthermore at the apex of the spore, there are two or more long, hyaline appendages or cilia. The acervuli always have a black appearance on account of the spores. As there are so many species, many of which have not been carefully worked over, it seems best only to mention a few of the more common forms.

Pestalozzia guepina Desm. This fungus occurs on the leaves of a number of different trees and shrubs and perhaps also some herbaceous plants. A variety of this species is also found on the cranberry. The acervuli are small and black. The conidia are about 20μ long and from three to four septate and have from three to four cilia or appendages.

Pestalozzia palmarum Cooke. This fungus is found on the leaves and fruits of various palms producing discolored spots. The conidia are fusiform, 4 septate and have three cilia. They average about 15 x 5-6μ.

Pestalozzia funerea Desm. This species also occurs on a wide range of hosts. It has been reported in this country on ginseng, appearing in a black velvety growth at the base of the leaves and flower stalks. The conidia are 4 septate, 22-32 x 6-8μ and have from two to five cilia.

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Pestalozzia uvicola Speg. This fungus attacks the fruit of grapes in this country causing a rot. The conidia are 4 septate, 35 x 8-10μ, and have three cilia.

THE GENUS CORYNEUM.

The genus Cornyeum with over 90 described species, contains a few forms that are more or less common. This genus differs from the preceding genera in spore characters. The spores are two to several septate and dark colored. They also lack the cilia or appendages that are characteristic of the genus Pestalozzia. A few of the species are parasitic but a great many are probably only saprophytes. As with the other genera, many of the species are not well known. Only two species will be mentioned.

Coryneum beijerinckii Oud. This fungus forms spots on the leaves, fruits, and buds of the peach often causing considerable damage. Many of the young buds are killed. The acervuli are produced sparingly in the spots. The spores are dark colored, rather large, and from two to several septate.

Coryneum foliicolum Fuckel. This fungus forms spots on the leaves of a number of different trees. In this country, it is frequently reported on the leaves of the apple. The spores are for the most part 4 celled and from about 13-16.5 x 4-5.5μ.

THE GENUS CYLINDROSPORIUM.

The genus Cylindrosporium with over 100 described species contains a few forms that are very common and important. This genus differs from those previously described in the characters of the spores. The spores of Cylindrosporium are hyaline, long filiform, and generally continuous. The acervuli are subepidermal and light colored. Only two common species will be mentioned.

Cylindrosporium padi Karst. This fungus is found on the leaves of various stone fruits such as cherries and plums, producing the trouble generally known as the "Shot Hole" disease. Small reddish spots develop which later drop out leaving small circular holes in the leaf. Before the tissue drops out, however, the small acervuli develop and shed the spores. The spores are long filiform, curved, and measure about 48-60 x 2μ.

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Cylindrosporium pomi Brooks. This fungus produces small spots or specks on the fruit of the apple. This trouble is very common in most of the apple districts of the country. The acervuli develop sparingly in these spots. The spores are hyaline, from one to five celled, variously curved, 15-80 x 2-2.5μ.

Literature

The literature dealing with the different species of the Melanconiales is very scattering. There are no monographs of any of the genera. The literature that is available is found mostly within scientific journals and Experiment Station bulletins. Below are given a few titles, including studies of a number of the different species in the different genera. Most of this literature is very easily obtained. Further references, if desired, can be found in the bibliographies given in these articles.

DUGGAR, B. M. Fungous diseases of plants. 1909.

EDGERTON, C. W. The physiology and development of some anthracnoses. Bot. Gazette 45:367-408. 1908.

EDGERTON, C. W. The bean anthracnose. La. Ex. Sta. Bull. 119. 1910.

EDGERTON, C. W. Some sugar cane diseases. La. Exp. Sta. Bull. 120. 1910.

EDGERTON, C. W. The red rot of sugar cane. La. Exp. Sta. Bull. 133. 1911.

LEWIS, C. E. Apple diseases caused by *Coryneum foliicolum* Fuckel and *Phoma mali* Schulz et Sacc. Maine Exp. Sta. Bull. 170. 1909.

SELBY, A. D., and MANNS, T. F. Studies on diseases of cereals and grasses. Ohio Exp. Sta. Bull. 203. 1909.

SHEAR, C. L. Cranberry diseases. Bur. of Plant Industry Bull. 110. 1907.

SMITH, R. E. California peach blight. Cal. Exp. Sta. Bull. 191. 1907.

STEVENS and HALL. Diseases of economic plants. 1910.

WOLF, F. A. A rot of grapes due to *Pestalozzia uvicola* Speg. Nebr. Exp. Sta. Report 21:69-72. 1908.

Louisiana Agricultural Experiment Station.

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DEPARTMENT OF NOTES, REVIEWS, ETC.

It is the purpose, in this department, to present from time to time brief original notes, both of methods of work and of results, by members of the Society. All members are invited to submit such items. In the absence of these there will be given a few brief abstracts of recent work of more general interest to students and teachers. There will be no attempt to make these abstracts exhaustive. They will illustrate progress without attempting to define it, and will thus give to the teacher current illustrations, and to the isolated student suggestions of suitable fields of investigation.—[Editor.]

THE CLEVELAND MEETING

In accordance with the vote at Minneapolis, the meeting of the American Microscopical Society in affiliation with the A. A. A. S., at Cleveland Dec. 31 and Jan. 1, will be a business meeting purely. The days are so full of special scientific meetings and the interests of our membership are so varied that it seems unwise to add to the competing meetings. The members of the A. M. S. who have papers prepared are requested to offer them before the appropriate section of the American Association, or before the affiliated special societies of which they may be members.

It has been found impossible to hold together any considerable body of members for general meetings in the presence of the attractive special meetings in which the majority of our membership are interested. This is taken by some to indicate that we should not meet at all under the shadow of these special sections and societies,—but should meet separately at some other period. The history of the last few years in which separate meetings of the A. M. S. were attempted tend to show, however, that the meeting of a society of such inclusive interests can no longer bring large numbers of members half way across the continent. Furthermore, scientific societies are too numerous now to allow us to expect such large accessions to our membership at the place of meeting, as was formerly the case.

These are some of the considerations that have led the present Secretary to conclude that it is wisest, at least for the present, to devote the time and money of the society to building up the *Transactions* as a journal of general interest, which shall bring to all the members more matter than would ordinarily be presented

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at a meeting. If the members wish the renewal of summer meetings this can be carried out after the society regains its full strength.

In this connection, it may be pertinent to suggest that, in the opinion of the Secretary, the Microscopical Societies of more local character should be able to carry on successful meetings. These may be state or city societies. There is no reason why really live, valuable meetings for practical discussions and demonstrations cannot be had under these circumstances. The number of people who use the microscope and are interested in its application is greatly increased. There are more indeed in a single city than were found in the whole nation when this society was organized. The A. M. S. stands ready to serve such local societies in any way possible. Indeed it seems as tho an effective division of labor would be: (1) the national society to furnish a magazine of microscopy and microscopic research; and (2) state and city societies to furnish the personal contacts and stimulus thru meetings. Some such broad affiliation of national and local societies ought to be possible, and mutually supportive.

The policy of concentrating the strength of the society on its Quarterly *Transactions* has, during the last two years, undoubtedly given the society the best growth it has ever had in the same length of time. None of this growth has been the artificial growth due to temporary and complimentary members secured at the place of meeting. The present growth is of individuals and libraries that find in the *Transactions* a promise of something they need. In the list of names when the present Secretary took charge there were 232 members and 33 subscribers. Of these 58 have died or definitely resigned during the last two years. Of the remainder, 36 have paid no fees. This leaves a net membership of 138 from the original list. Three subscribers have discontinued. Seventeen new subscribers have been added, making a total of 47. A total of 161 members and subscribers has been added. There are now listed 271 paying members, or 318 members and subscribers. We have not yet been able to reach the self-supporting membership of 400 for which we have been hoping, but we have more than made good the earlier total membership. Two more years of growth equal to the past two will give an income sufficient to print the *Transactions* on a scale that will be a credit to the society and to science.

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The Secretary feels that this result can be quickly attained by the sympathetic efforts of the members to extend information of the society and its *Transactions* among their friends. The Secretary cannot do this. The individual member can.

MIMICKING THE AMEBOID AND STREAMING MOTIONS OF PROTOPLASM

Robertson (Science Oct. 4, 1912) reports a method of mimicking the motions of protoplasm in the Ameba which he claims is very striking and instructive.

1. *Ameboid Motions.* Prepare a 10% solution of camphorgum in benzol. Color this deeply by the addition of Sudan III or Scharlach R. Place a drop of this mixture upon the surface of water. Thru the alterations of surface tension, lengthy and irregular "pseudopodia" are rapidly thrown out and withdrawn.

2. *Streaming Motion.* Add to portions of the solution described above olive oil or other viscous liquid, and place drops of the mixture on water as before. By increasing the amount of the oil the alterations of form are less and less rapid; but the internal streaming is energetic and striking.

RELATIONS OF BLOOD TO SIZE IN RABBITS

Boycott (Jour. Path. and Bact., April, 1912) summarizes the results of studies on the relation of the size of rabbits to growth and quality of blood therein, as follows:

1. Small rabbits are found to have a larger percent of haemoglobin, and more blood and haemoglobin in proportion to body weight, than large rabbits.

2. Male rabbits appear to have more haemoglobin per unit of blood than the female.

3. After the suckling period, rabbits have at least haemoglobin relatively to the body weight when it weighs 1.5 to 2 kilos.

4. A rabbit of 2 kilos has about 6.5 c.c. oxygen capacity and about 45 c.c. of blood per kilo of body weight.

CULTURE OF MALARIAL PLASMODIA

Bass and Johns (Jour. Exp. Med. Oct. 1912) report the results of successful cultures of malarial plasmodia *in vitro*. This relates to the asexual cycle, tho the authors found suggestions of the sexual.

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The asexual cycle of *Plasmodium vivax* and *P. falciparum* were grown in vitro in human blood and in red blood cells in Locke's solution. There is evidence that the parasites cannot grow outside the red blood cells. Leucocytes devour the malarial plasmodia grown *in vitro* only when the parasites escape from red cells. By removing leucocytes, successive generations of both species may be had by adding fresh red cells and serum at proper intervals. The generation period varies greatly with temperature and probably with other conditions.

PURE CULTURES OF SPIROCHAETA IN VITRO

Noguchi (Jour. Exp. Med. Aug. 1912) describes the pure cultivation of several species of Spérochaeta and *Treponema pallida* in vitro. The conditions are: a temperature of about 37°C.; fresh sterile tissue, and a body fluid capable of forming a loose fibrin with the tissue; and some oxygen.

The germs do not lose wholly their pathogenic quality by such cultivation, tho the virulence seems diminished.

Both longitudinal and transverse division of these organisms is affirmed by the writer.

NOTES ON POLLEN

Lord Avebury gives (Jour. R. M. S., Oct. 1912) in popular form many facts relating to pollen,—its structure, development, variations in size, form and surface, colors, etc. He includes a table giving length of the pollen grain and length of pistil. He concludes that there is a distinct relation between these, especially convincing when nearly related species are compared. The article concludes with a summary of the family traits of the pollen of the various natural orders of plants.

ROOT NODULES IN PLANTS OTHER THAN THE LEGUMINOSÆ

Since the discovery that atmospheric nitrogen is assimilated by leguminous plants thru the action of symbiotic bacteria in the nodules of the roots, it has been an open question as to how widely this relationship and this power extend in the plant kingdom. In the investigation of this question it has been found that root nodules exist in Cycadaceæ, Elæaginaceæ, in *Alnus, Podocarpus,* and *Myrica.*

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Spratt (Am. Bot., July 1912) reports studies of several genera of the Podocarpineæ and finds root nodules on all examined. These nodules are modified lateral roots. They are produced by the infection of the meristematic tissue of the young root, by *Pseudomonas radicicola,* shown to be identical in cultures with the infesting bacterium in Leguminosæ. Cultures also show these organisms capable of assimilating atmospheric nitrogen.

A PLEA FOR THE FISH

"When removing an undersized trout from your hook, always moisten your hands before grasping the fish; otherwise the dry hand will remove the slime from the back of the trout, when it is only a question of time until fungus sets in and the fish will die.

Always kill your fish that are large enough to keep, as soon as taken from the hook. This can be done by giving it a stroke with a stick on the head, back of the eyes. It will avoid all suffering and make your fish far better for table use.

The American Fisheries Society at Washington, D. C., September 21-24, 1908, recommended that the various State Commissions educate the people by every means in their power to follow the directions given about wetting the hands.

Indorsed by twenty-eight Fish and Game Commissions throughout the United States."

G. H. Thompson, Fish Culturist,
Superintendent of the Estes Park Fish Hatchery.

HEREDITY IN RELATION TO EUGENICS

This book, by Dr. C. B. Davenport of the Carnegie Institution, is an effort to bring together, in a form that the intelligent worker even tho not a special student of biology may comprehend, some of the results derived from our modern studies of heredity, the methods whereby these results have been reached, and certain applications of these methods to the study of human traits and thru these to human guidance. The book ought to serve in a very real way the social worker, the physician, and the teacher of general biology. Dr. Davenport is one of the leading American students of this subject.

In Chapter I on "Eugenics: Its Nature, Importance and Aims", the writer defines the scope of this new hope that the quality of the

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human race may be definitely improved by proper breeding,—as definitely improved as the breeds of domestic animals have been. Unless scientific principles come to influence marriage selection, human progress will cease.

Chapter II discusses the scientific method whereby our progress is now being made in the study of heredity, and the application of this method and its results to human breeding.

In Chapter III a great mass of material relating to the inheritance of family traits is brought together. It is shown that many qualities are inherited in accordance with the Meudelian expectation. Among these are color of eyes and hair; stature; musical, artistic, literary ability; mechanical skill; memory; temperament; mental ability; insanity; criminality; many defects of body and mind leading to disease; and numerous other personal characteristics.

Chapters IV and V deal with the Geographic Distribution of Inheritable Traits as determined by barriers, migrations, etc.

Chapters VI and VII deal with concrete American instances in which individuals with marked personal characteristics have impressed in special degree the lines of descent springing from them; and instances of marked family traits which persist for generations.

In Chapter VIII the author discusses the relation of Eugenics to Euthenics,—of the heredity influences to the environmental influences in molding the future of the human race. This is a very suggestive chapter and should be appreciated by all social workers.

The concluding chapter has to do with the relation of organized society to the matter of Eugenics, both as to the studies which must be prosecuted and to the application of the result in social control.

A good bibliography and index add to the usefulness of the book.

Heredity in Relation to Eugenics, by Charles B. Davenport. Illustrated; 298 pages. Henry Holt & Co., New York. Price, $2.00; by mail, $2.17.

HEREDITY AND EUGENICS

This book is a composite product of several men who, among Americans, are the leaders in the recent experimental study of heredity. It contains a somewhat popularized summary of the re-

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cent advances of our knowledge of variation in plants and animals, of inheritance, and of evolution. It is entirely authoritative, and brings to the general student a dependable digest of the best conclusions in this department of investigation. This digest is similar to the summaries which are being given from time to time, in the *Transactions,* of the various special fields of biological research.

The chapters were originally given as lectures during the summer quarter of 1911 at the University of Chicago. The lectures quite naturally overlap to a certain extent.

Professor Coulter introduces the subject in a lucid way with two general lectures:—Recent Developments in Heredity and Evolution, and The Physical Basis of Heredity and Evolution from the Cytological Standpoint.

Professor Castle offers two chapters on The Matter of Evolution, and Heredity and Sex. In these chapters the general outline of Mendelism is given and its relation to other methods of evolution suggested, especially in the animal kingdom.

In Professor East's chapters the application of Mendelism is made to plant inheritance and breeding. The chapters are entitled:—Inheritance in Higher Plants, and Application of Biological Principles to Plant Breeding.

In Chapter VII, Professor Tower discussed the possibility of modifying the nature of the reproductive material of organisms by experimental processes, in such a way as to change inheritance from the outside. Professor Tower by no means confines his discussion to his own remarkable work on the chrysomelid beetles; but this work gives him added authority to discuss that of other people and is the backbone of his contribution. This part of the book has been less exploited elsewhere than the matter in the other chapters, and will prove somewhat more difficult to the general reader.

In the concluding lectures Dr. Davenport makes the application of the laws of organic heredity to man. The titles of Chapters VIII and IX are:—The Inheritance of Physical and Mental Traits of Man and Their Application to Eugenics; and The

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Heredity and Eugenics, by Castle, Coulter, Davenport, East, and Tower. University of Chicago Press, 1912. 315 pages, illustrated. Price, $2.50; by mail, $2.70.

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Geography of Man in Relation to Eugenics. These chapters are drawn largely from Dr. Davenport's book reviewed above.

THREAD ATTACHMENTS BETWEEN NUCLEAR AND CYTOPLASMIC BODIES

I have read with much interest Mr. E. W. Roberts' article, "The Modern Theory of the Cell as a Complex of Organized Units," in *Transactions* of April, 1912.

Being an ardent worker in Cytology and having spent some years in trying to unravel a few of the many existing cytological problems, I was particularly attracted by some of the remarks and views advanced by Mr. Roberts in his highly attractive and interesting contribution.

Although many of Mr. Roberts' remarks appear at present of a very speculative character, and will require, possibly, many years of close microscopical work before they can either be proved or disproved; yet to me whilst reading them they have a charm of their likely possibilities.

Work in connection with a subject such as this presents great difficulties, both concerning the microscopical as well as the chemical character of the cell.

I was not aware of the fact until I read this paper that the cells of *Spirogyra* during life contained connecting filaments between each pyrenoid body and the nucleus; although I have examined *Spirogyra* many times in connection with various cytological work; this only proves to me how easily most important structure may evade the careful searchings of, I think I may say without egotism, a trained eye.

Apart from perhaps another point of interest in this cytological contribution the finding of the presence of these connecting filaments, *if beyond doubt,* is a wonderful achievement and a splendid addition to present knowledge of the complexity of the cell. I think Mr. Roberts is quite correct in his statement, that the question whether these connecting threads exist between the vegetative and nuclear groups of other types of cells is a field that has been entirely untouched up to the present.

Seriously considering the value of further development in this line of research, I felt myself irresistibly compelled to make investigations in this direction.

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I chose for my subjects to work upon *Allium* and *Hyacinthus*. In my laboratory work, these have been almost classical objects and I have done an endless amount of work upon them for years past. Accordingly I was most anxious to ascertain whether the keen attention which I had given to the examination of other detail and structures, upon which I was working, had so clouded my eyes that it had shut out from view the possible presence of threads connecting nuclear with protoplasmic bodies.

At first I resolved to examine again some of my many and valued sections illustrating highly interesting phases in mitosis. This I did, but after their once more careful study, I was unable to convince myself of the presence of any structures such as Mr. Roberts described in *Spirogyra,* although there were several instances which left conflicting doubts in my mind. Considering some of these specimens again on another occasion, I came to the definite conclusion since nearly all of them were stained and specially differentiated in order to show the nucleus and nuclear structures only, leaving the surrounding protoplasm almost indistinct by contrast, that it was evident such a contrast of the staining between these two structures was useless in order to establish the presence or non-presence of these nuclear attachments.

After a number of efforts to get a uniform stain, I succeeded by cutting some extremely thin transverse sections (2μ) of *Allium* (growing root tips). These I fixed in the usual manner to the slips *without* the aid of fixitive (this latter procedure can readily be understood as most important when fine detail is to be searched for). I have always found that it is much easier with very thin sections to get equality of staining by carefully watching the differentiation process under the microscope. This is not the case with thicker sections, say 10μ or more. The nucleus in these thicker sections still holds the stain deeply even when that in the cytoplasm has been entirely extracted. As mentioned above I felt confident that this equality of stain over the whole cell inclusion was absolutely important and essential to future success, and could only be obtained by working upon very thin sections.

When the time came to examine these last preparations, using critical illumination with oil immersion, condenser, etc., my hopes

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and expectations were rewarded. Although not present in the majority of cells, there were many in which distinct filar attachments could be seen between chromatin bodies in the nucleus and granules in the cytoplasm. They were not numerous in the individual cells, the most I counted was two, and in a very few instances *three*. The fact of their apparent scarcity and not finding more than three in any one cell examined, may quite possibly be accounted for by the extreme thinness of the sections and the plane of cutting. As far as I can at present make out, these structures cannot be seen when the cell is not strictly in a vegetative condition. However, notwithstanding the comparative few cases in which they could be observed, the fact of their being distinctly seen in many cells and in several separate sections of different series, may be taken, I think, as proof of their being present in the cells of the growing root tips of the onion.

Up to the present I have not had the time to cut and examine similarly treated sections of the root tips of *Hyacinthus*, but I feel almost certain they will not be found missing here, and before long I hope to be able to extend my work and observations in this direction to other vegetable tissues as well as some of the various animal cells. I adopted Heidentain's iron haematoxytin method of staining, giving baths of not less than twelve hours both in the iron solution and the haematoxytin and differentiating *slowly* in a very weak solution of the iron alum. I think twenty minutes at least should be taken for this purpose. It seems to me useless to attempt any work upon sections that are much over 2μ in thickness for reasons already stated. I am inclined to think that it would be an advantage to the above process to use as counter stains eosin and acid rubin, particularly a watery solution of the former. This in my hands works very well after staining with iron haematoxytin. It is not always easy to prevent diffused staining with acid rubin, but when successful results are obtained with either eosin or rubin even better observation results may be expected.

In conclusion I feel sure there is much of great interest awaiting the careful and persevering worker in this field of research, and in the event of these filar attachments between nucleus and

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cytoplasm being proved a constant feature it is difficult at the moment to appreciate their full meaning.

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NEW MODELS IN BINOCULAR MICROSCOPES

The optical works of Ernst Leitz, Wetzlar, Germany, have introduced a new model of Binocular Microscope, which they designate as the "Greenough-Leitz." It is interesting to note that new ideas have effected a considerable change in construction of this particular model in comparison with the older forms.

The new principles involved in the construction of the "Greenough-Leitz" are the result of frequent demands made upon manufacturers to provide certain modifications. The illustration (Fig. 1) will convince the reader that unusual stability is featured in the instrument. The coarse adjustment by rack and pinion is situated in the column of the stand, independent of the prism tubes, the latter being permanently a part of a heavy bent arm which is in turn attached to the rack arrangement of the stand.

FIG. 1

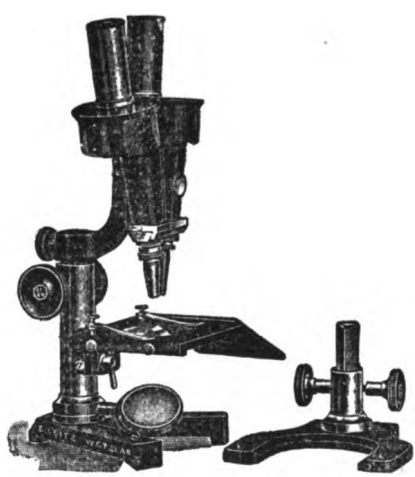

FIG. 2

As a Dermatoscope and for the examination of large surfaces an arrangement is provided as shown in Fig. 2. The auxillary

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foot is of hard rubber and carries a separate rack and pinion coarse-adjustment. The curved arm carrying the prism tubes is readily adapted to the column of the hard rubber foot.

FIG. 3

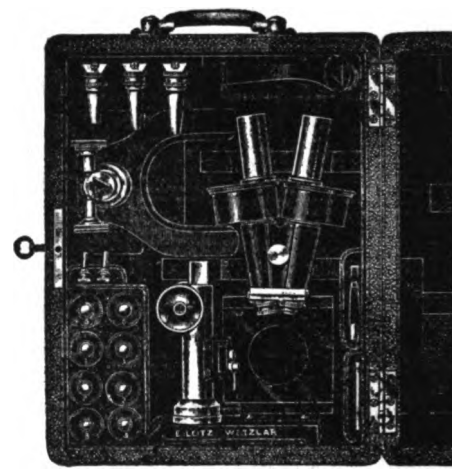

FIG. 4

Of still further interest to most all scientists is the fact that the "Greenough-Leitz" is also made in folding form, for the convenience of those who wish to carry the microscope into the field. Fig. 3 shows the provisions for this arrangement, viz: the folding foot and the microscope stage mounted so that it can be swung vertically in the microscope axis. The manner of placing the entire equipment in a case is illustrated by Fig. 4. Compactness is featured here and the result is that the demand of those actively engaged in field work for an outfit of this construction has at last been gratified.

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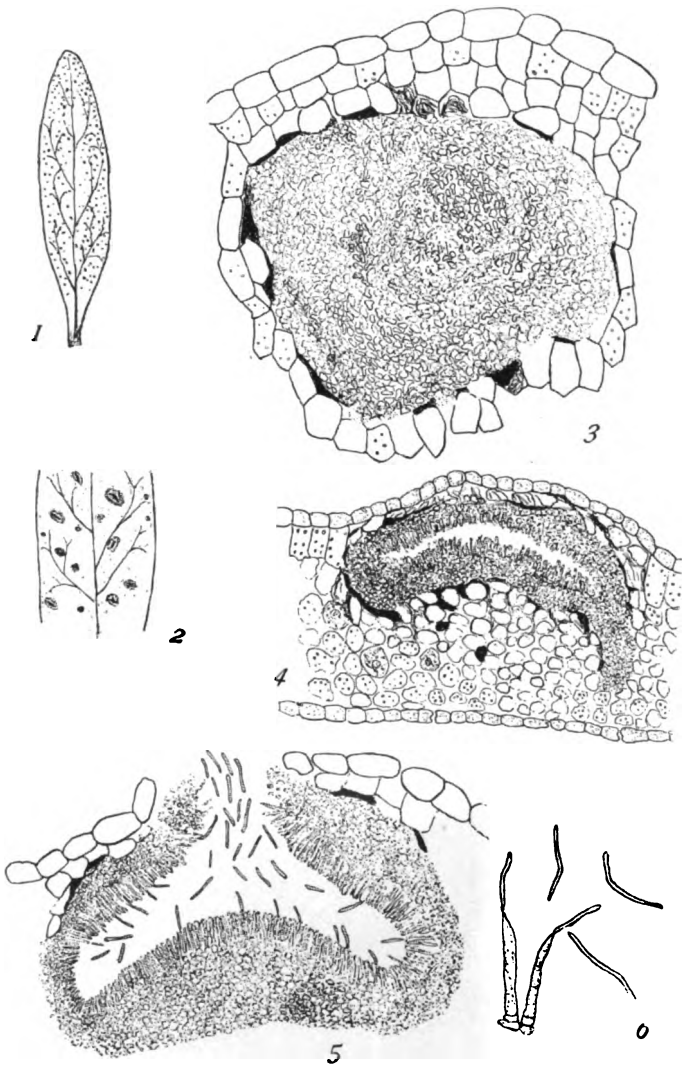

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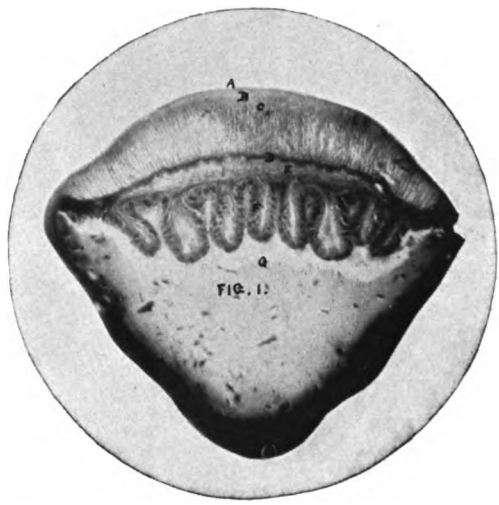

Fig. 1. Photograph of the footpad of the grasshopper.

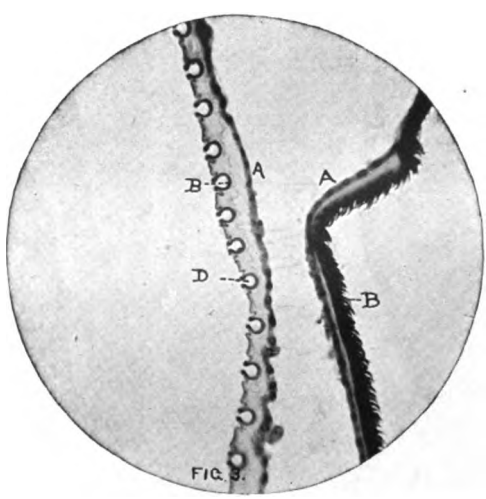

Fig. 3. Photograph of a section of the tongue of Horse-fly, showing the pseudo-tracheal grooves.

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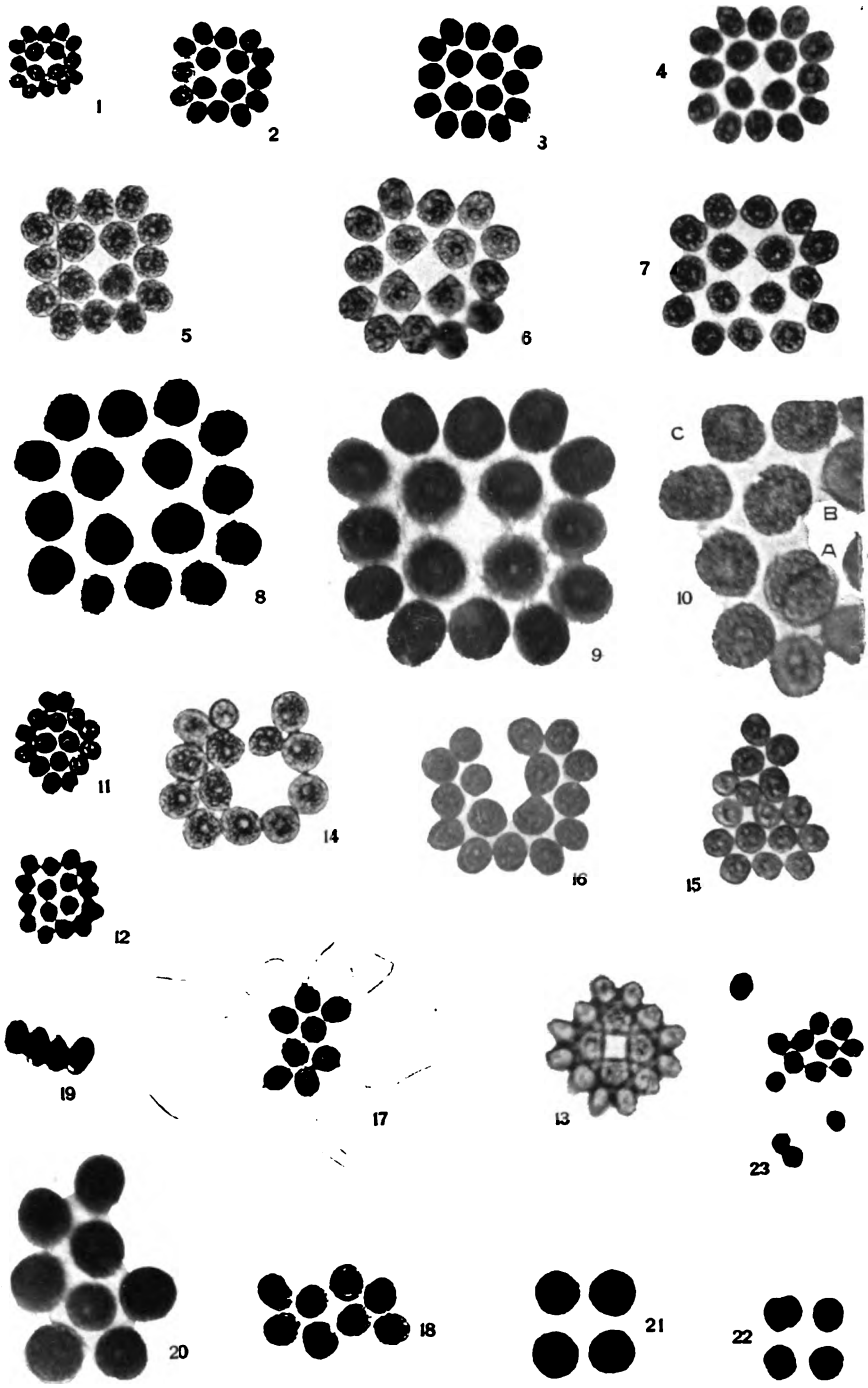

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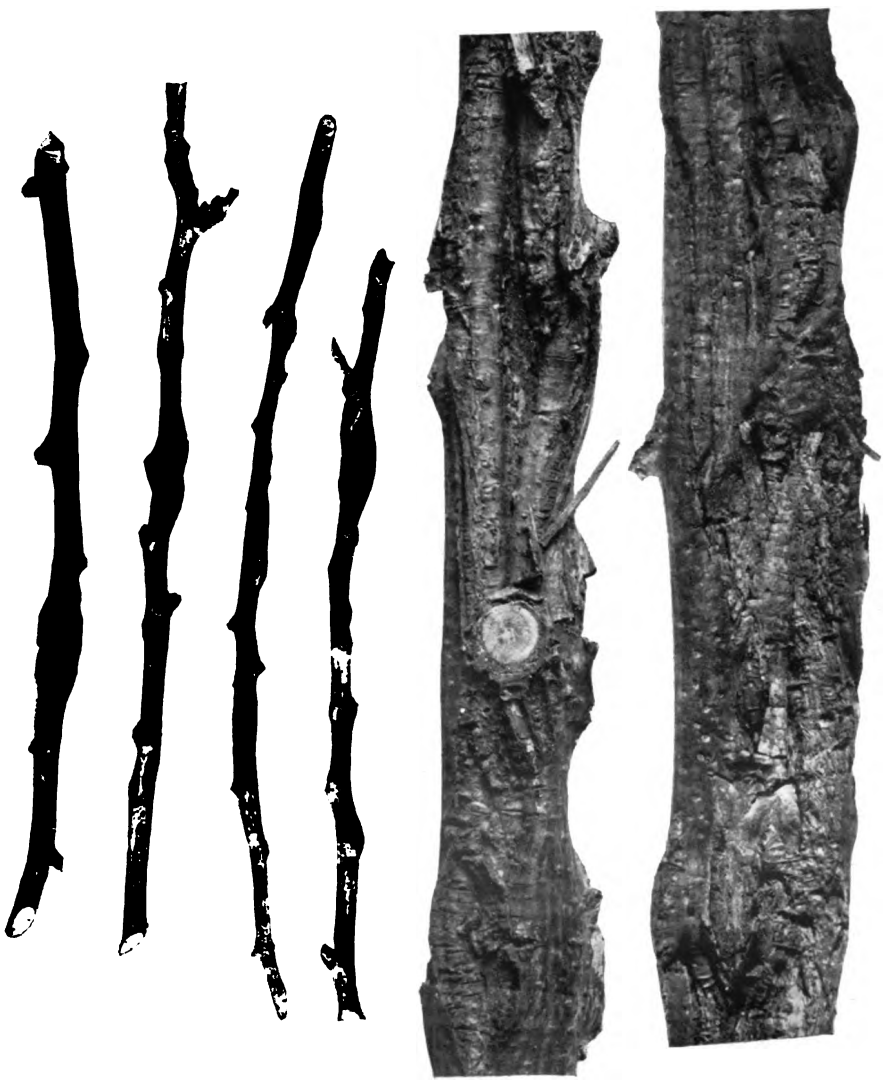

PLATE XIV

Plum Cankers caused by *Pseudomonas pruni*. Twigs at left one year old; at right six years old.

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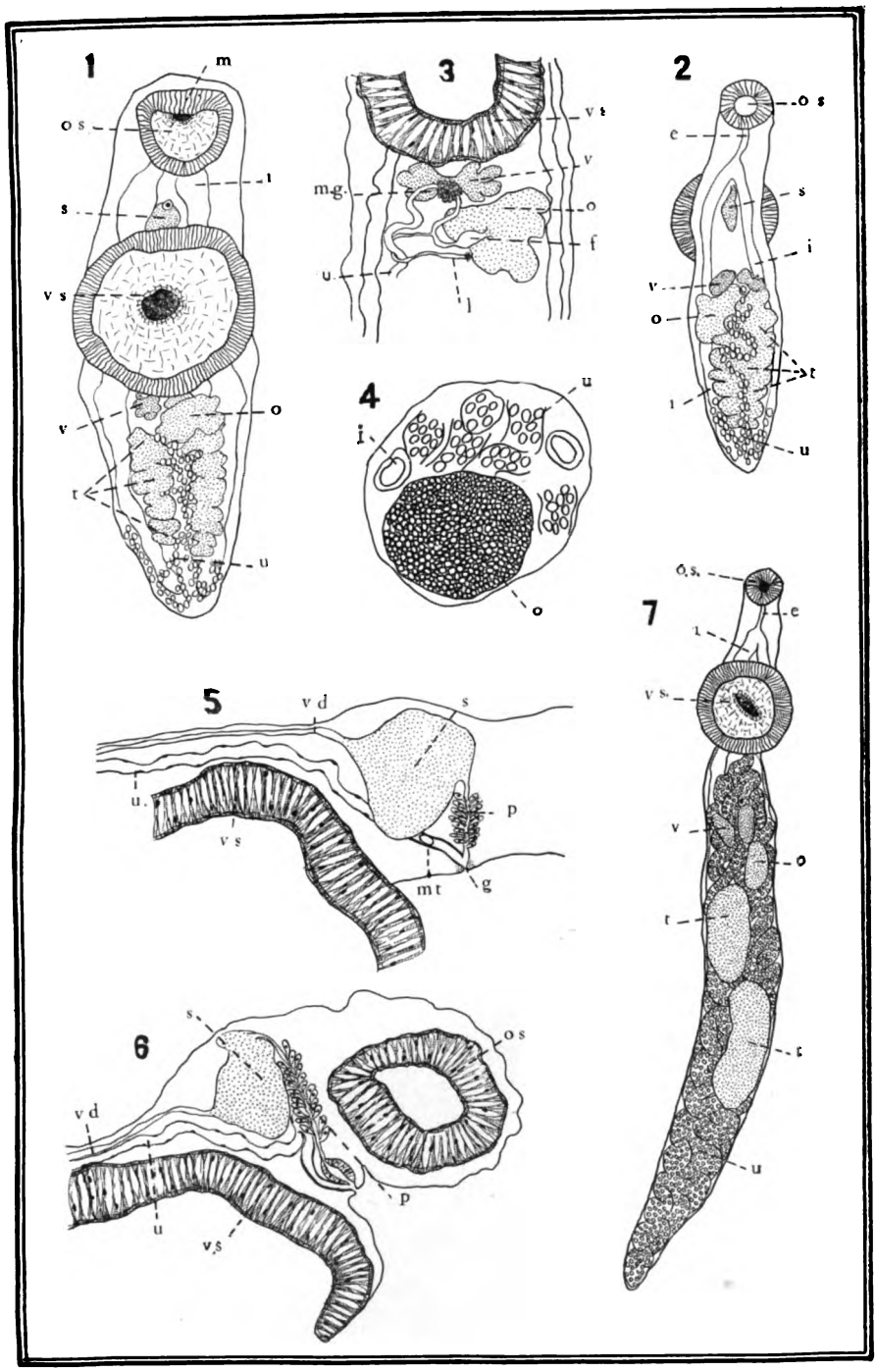

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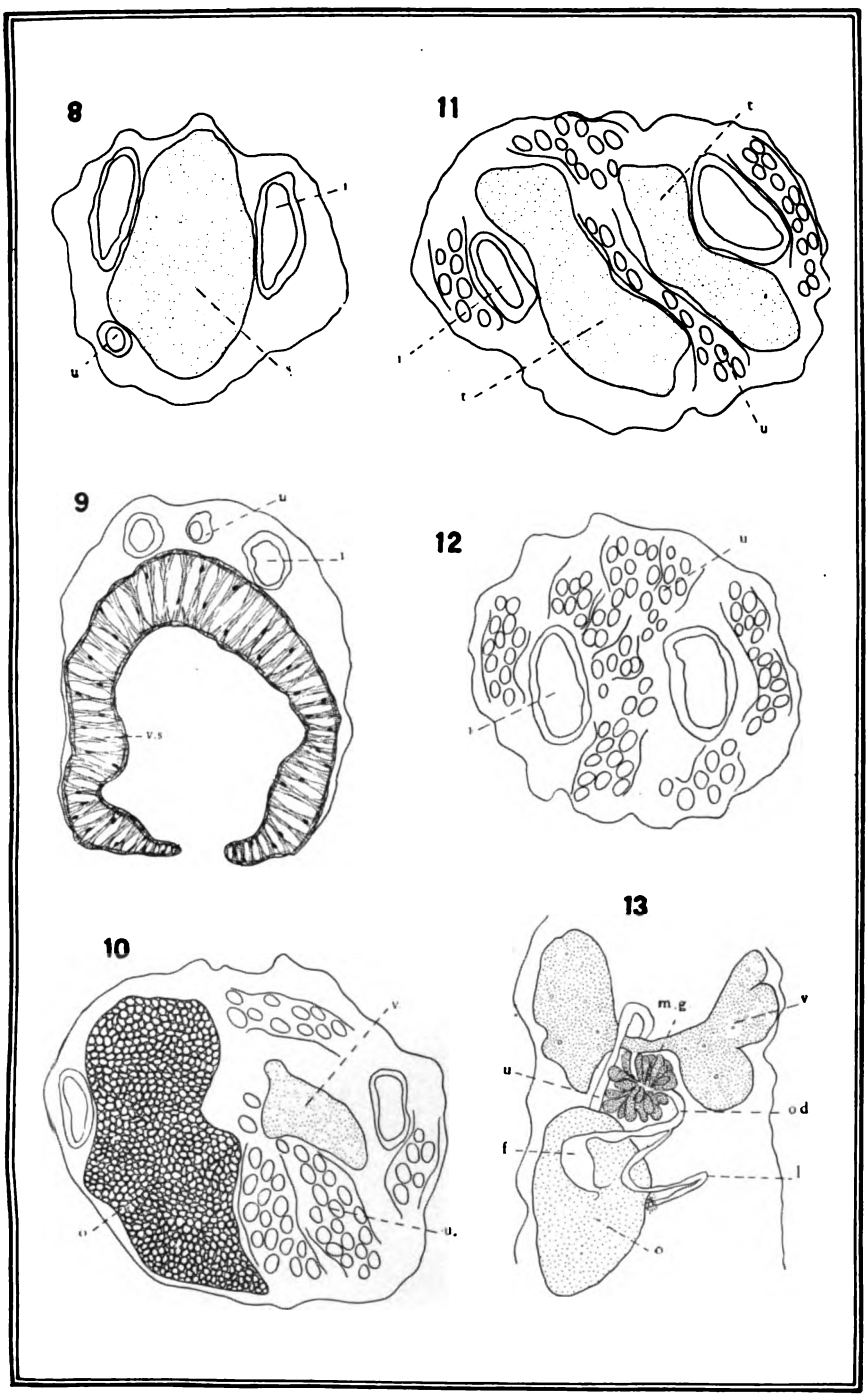

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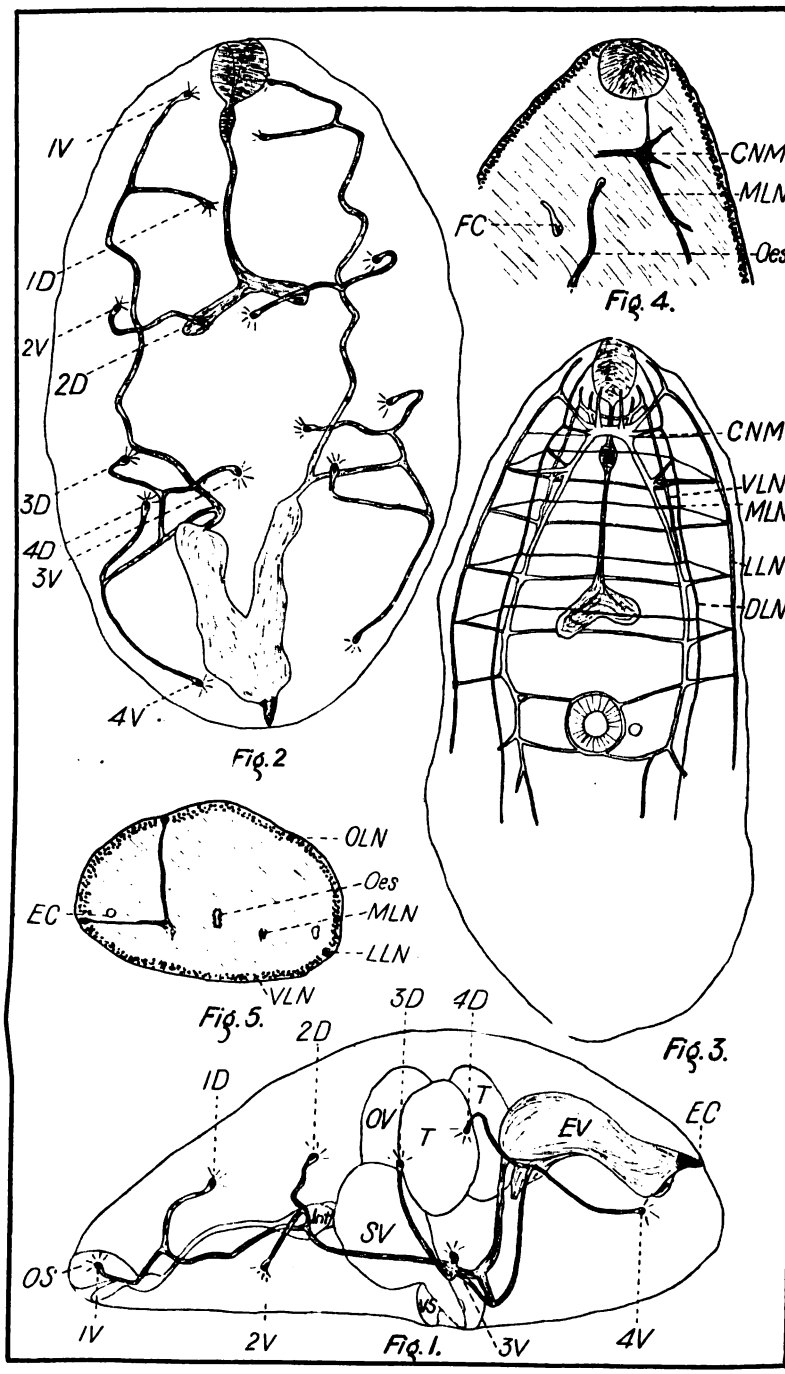

PLATE XVII

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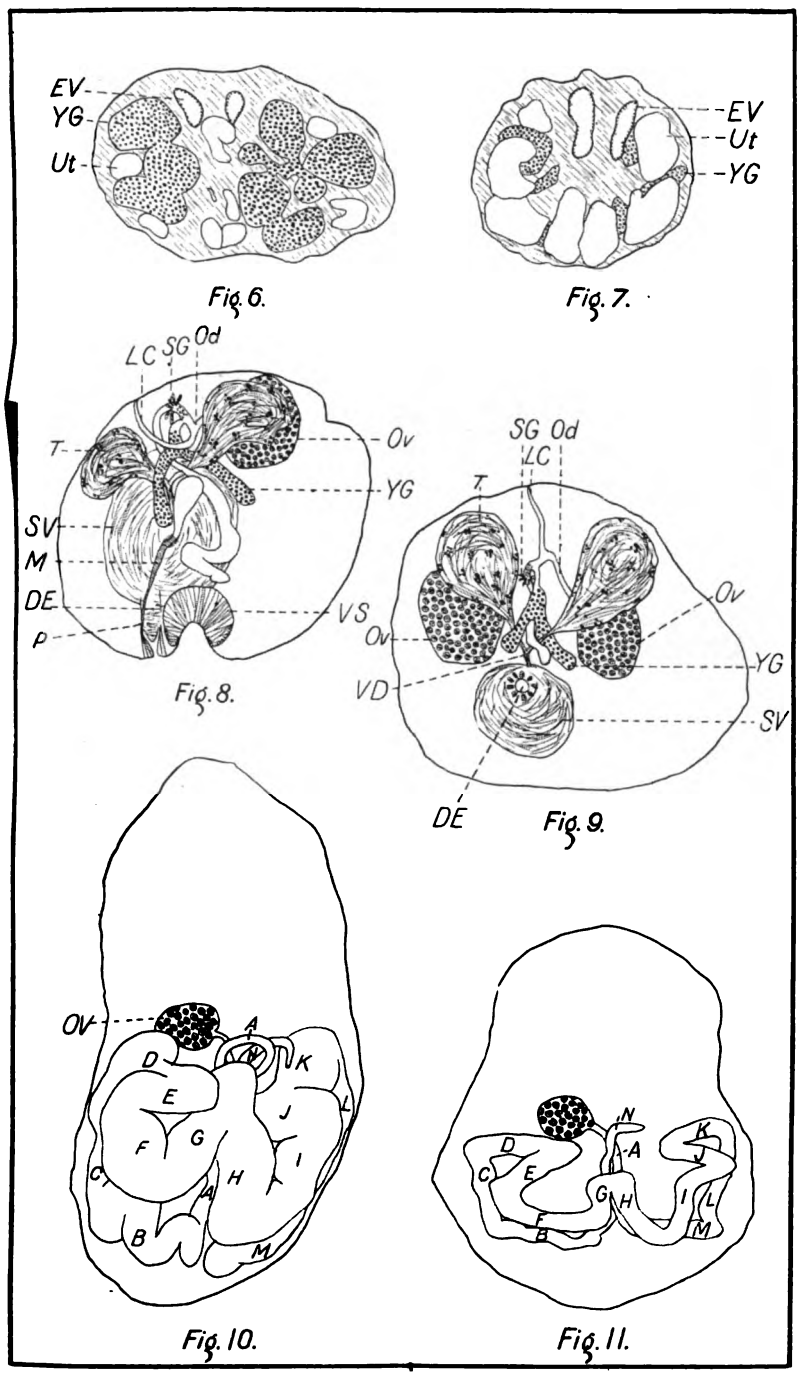

PLATE XVIII

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PLATE XIV

Plum Cankers caused by *Pseudomonas pruni*. Twigs at left one year old; at right six years old.

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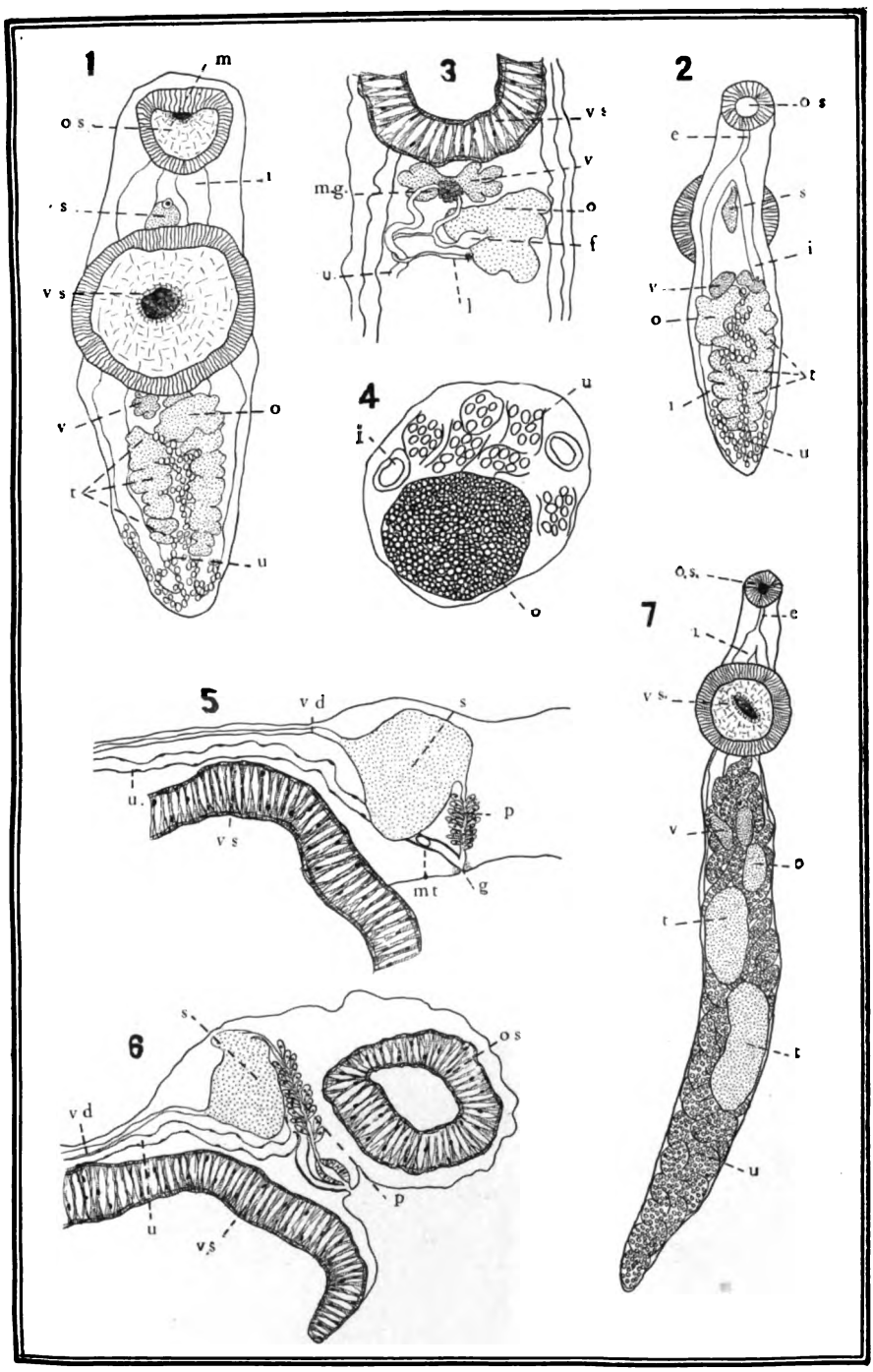

PLATE XV

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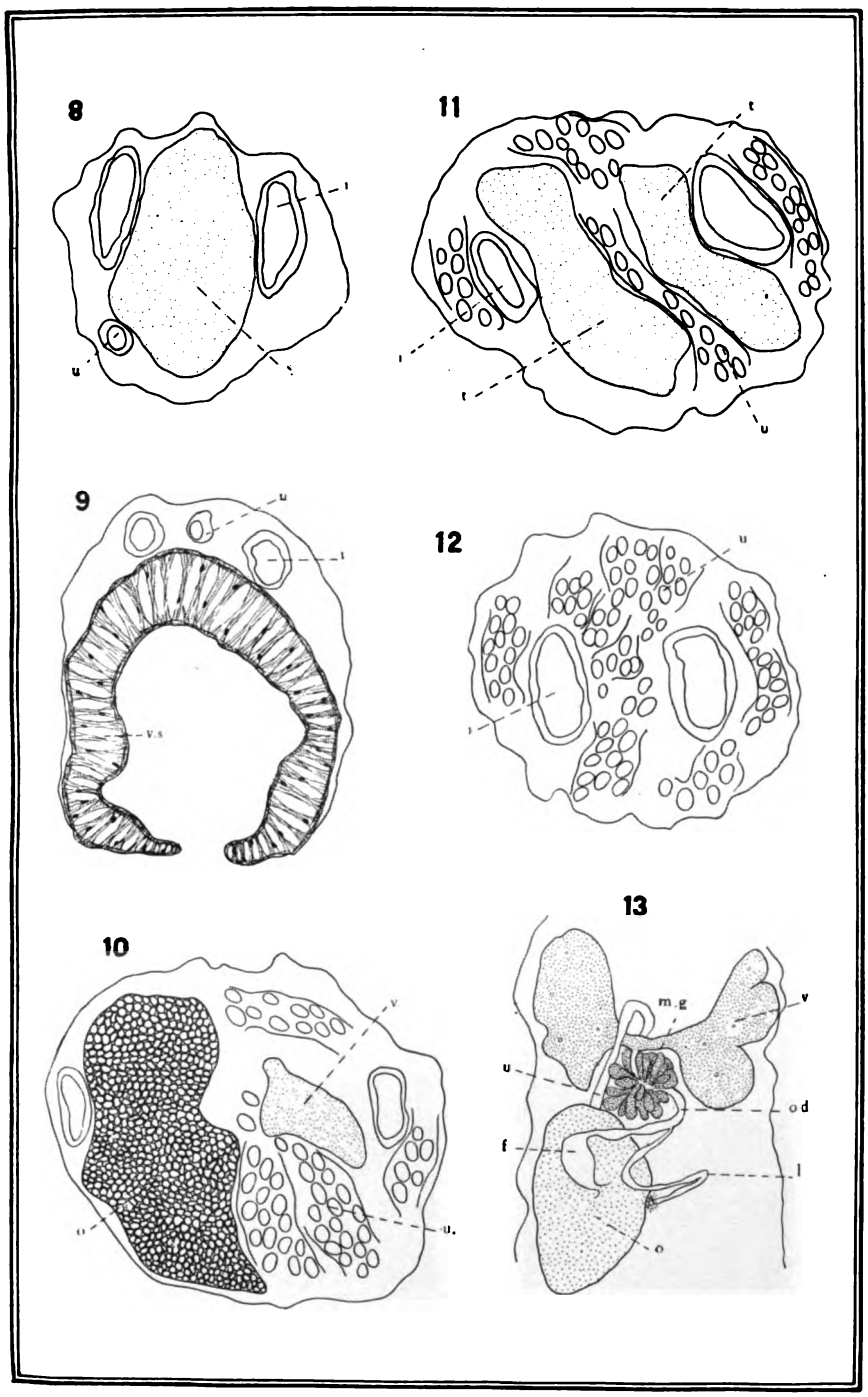

PLATE XVI

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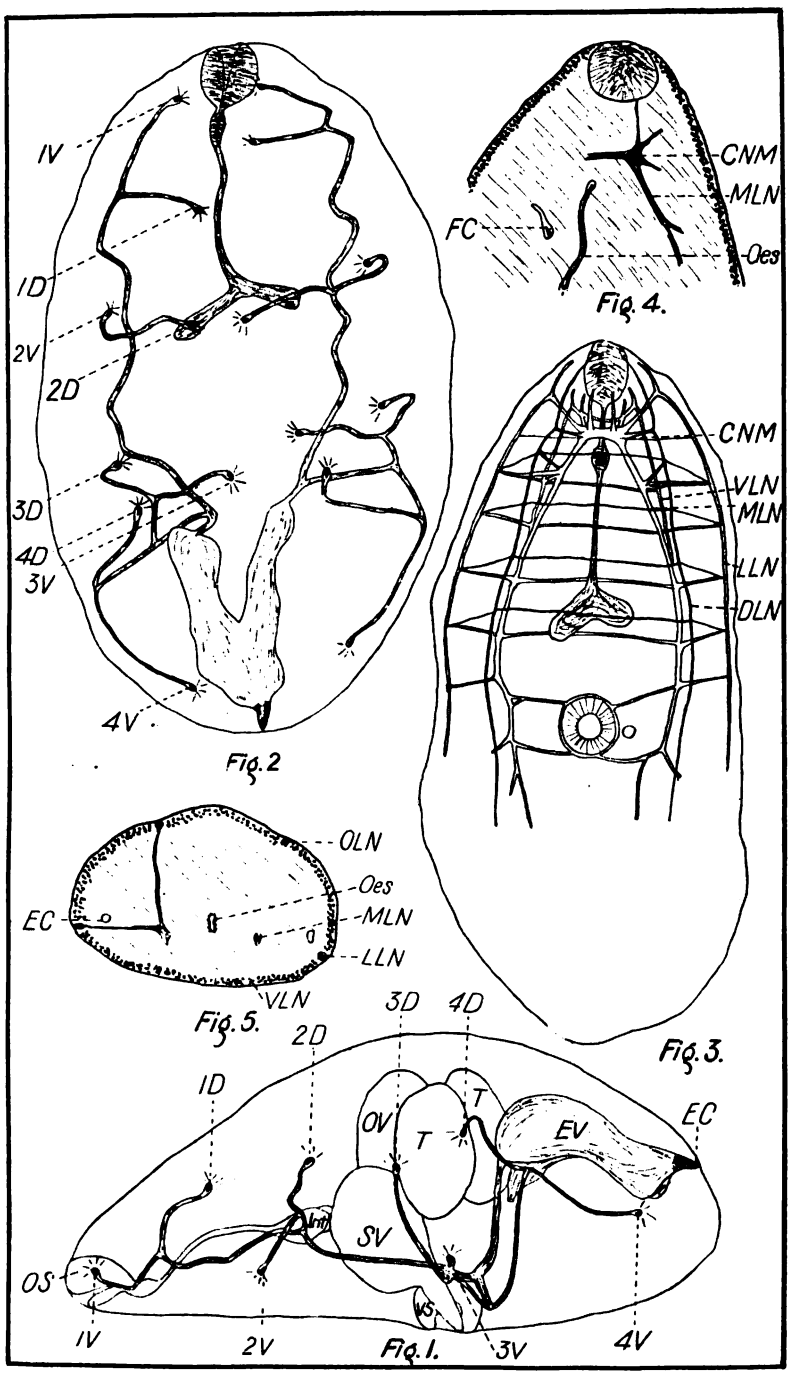

PLATE XVII

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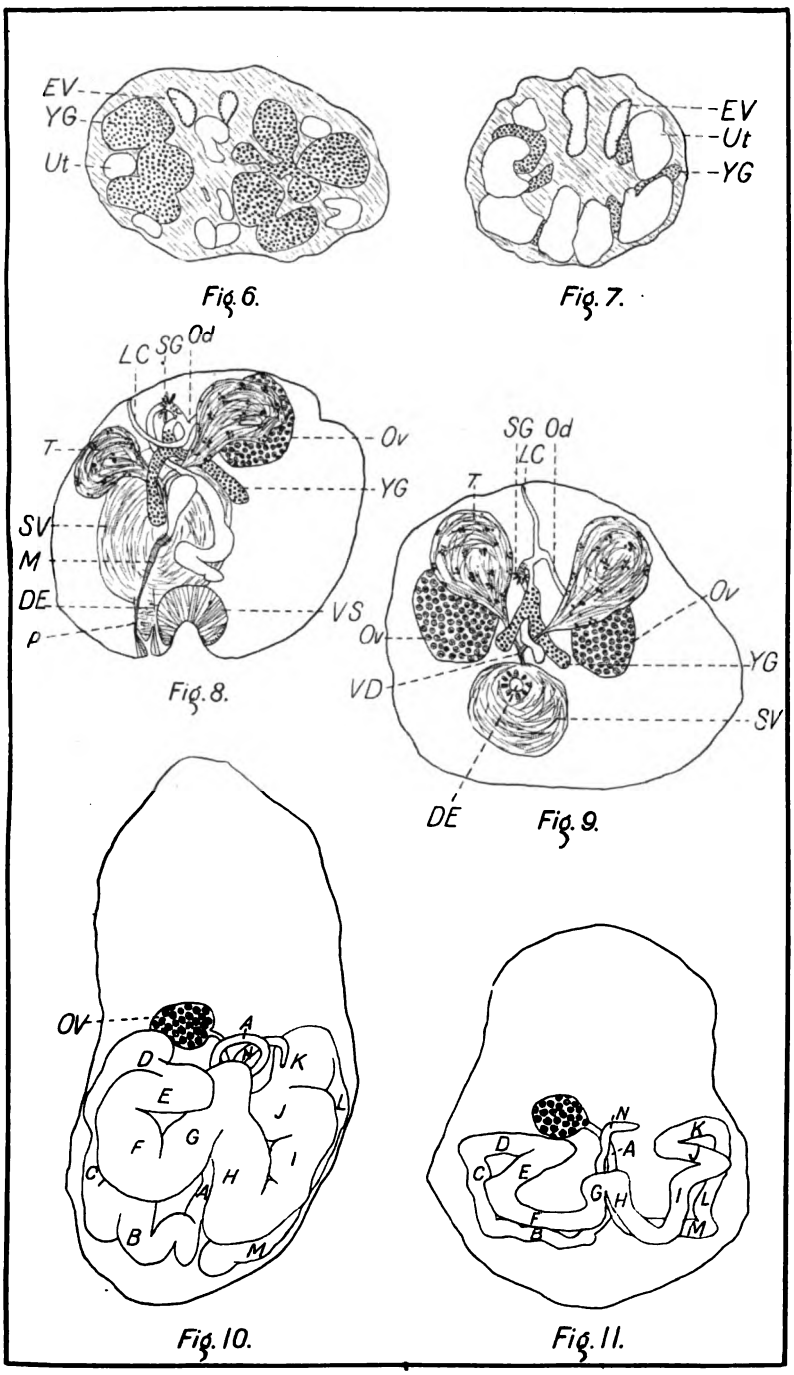

PLATE XVIII

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Plate XIX

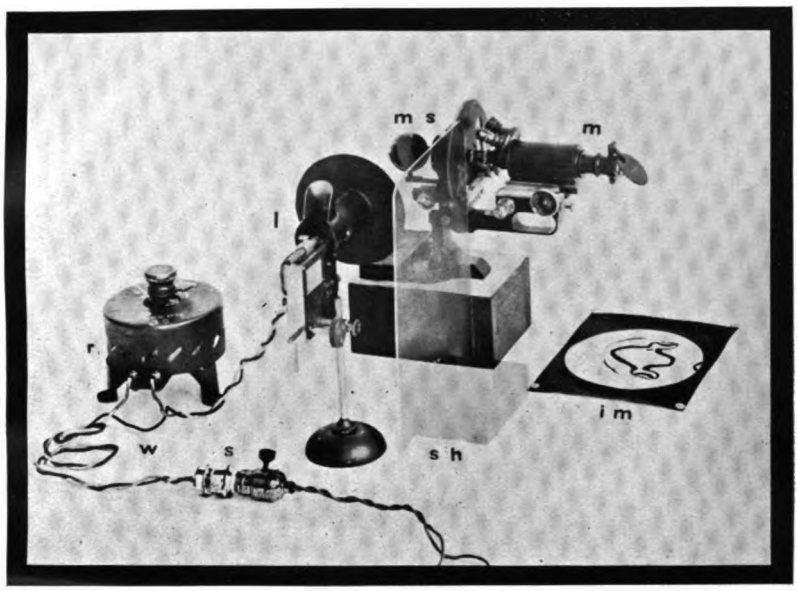

Fig. 2

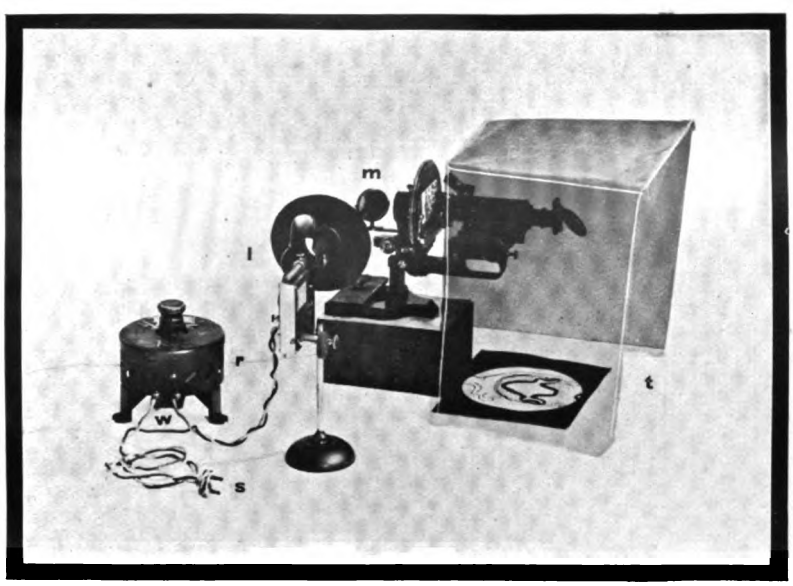

Fig. 3

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Plate XX

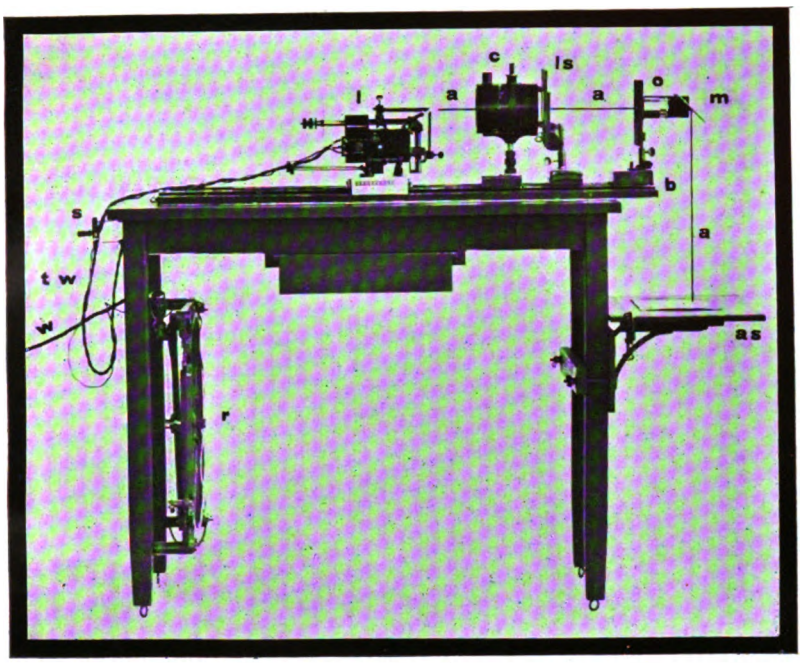

Fig. 5

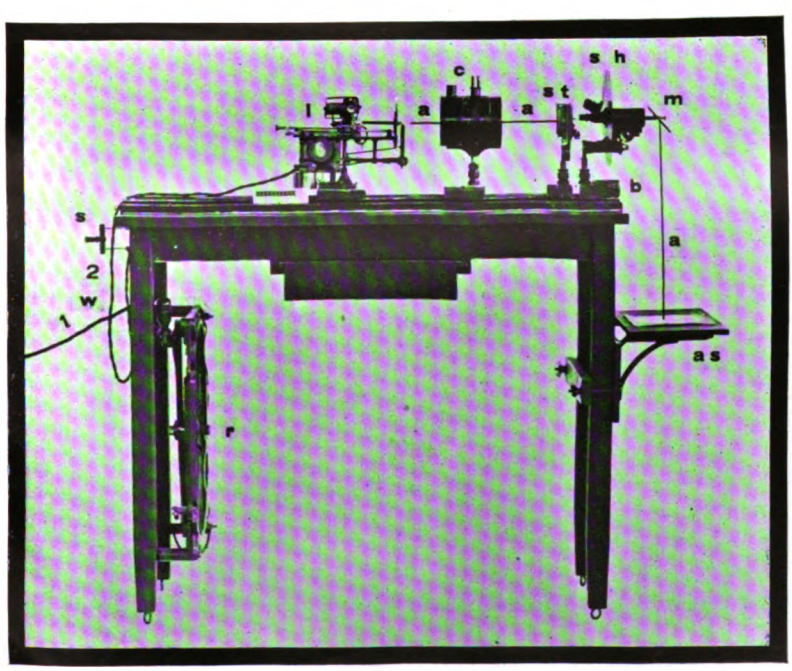

Fig. 7

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Plate XXI

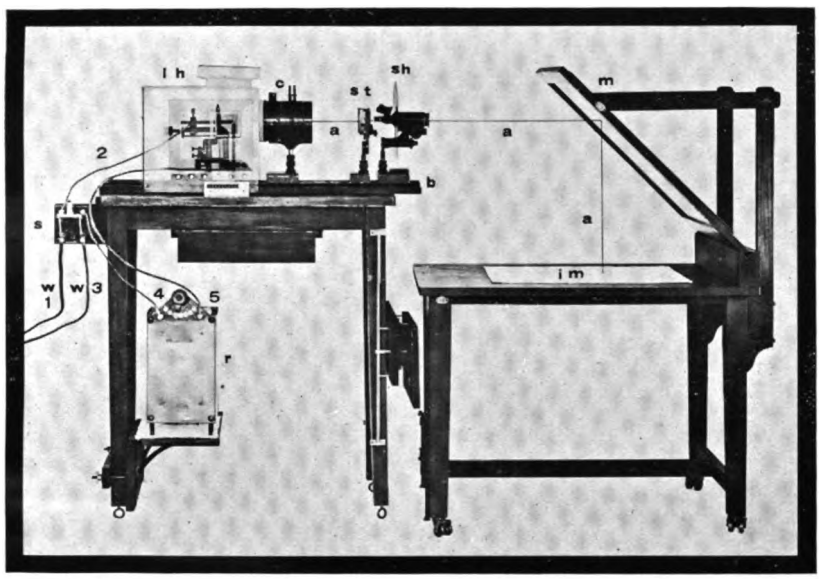

Fig. 8

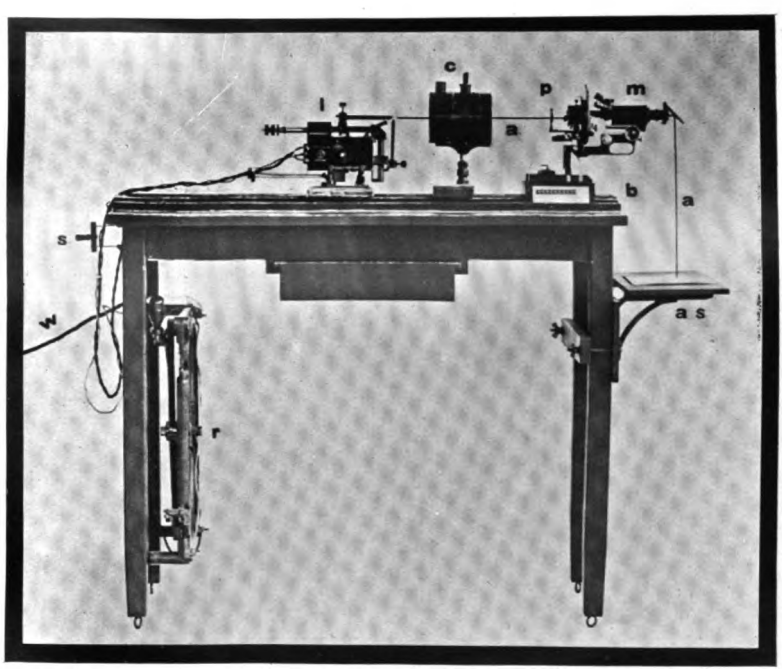

Fig. 9

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Plate XXII

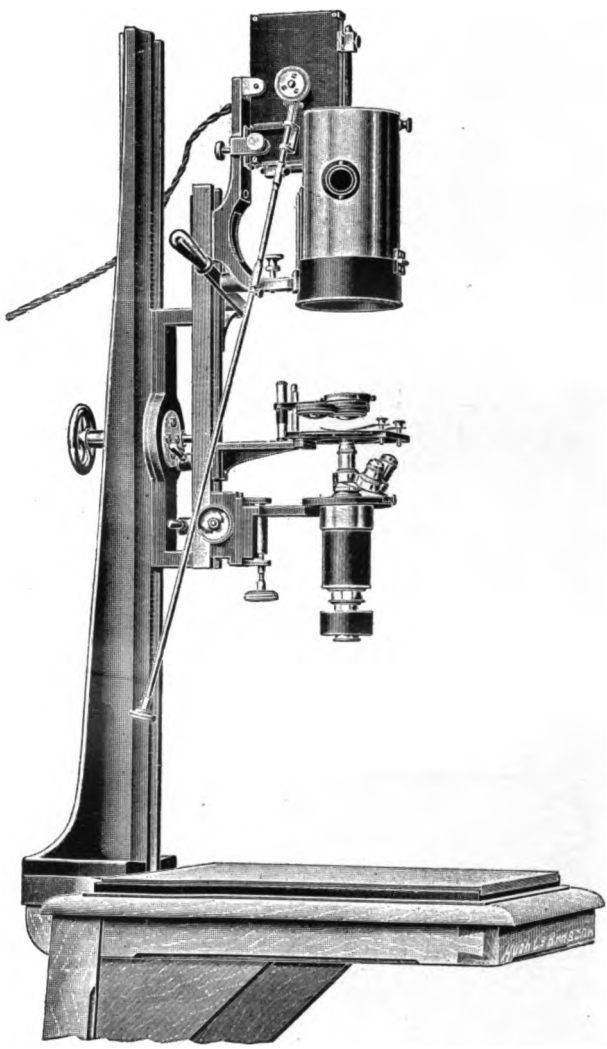

Fig. 11

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Plate XXIII

Fig. 12

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Plate XXIV

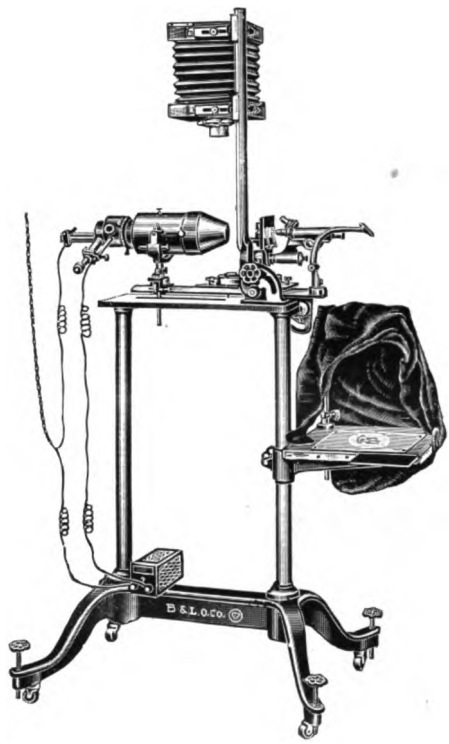

Fig. 13

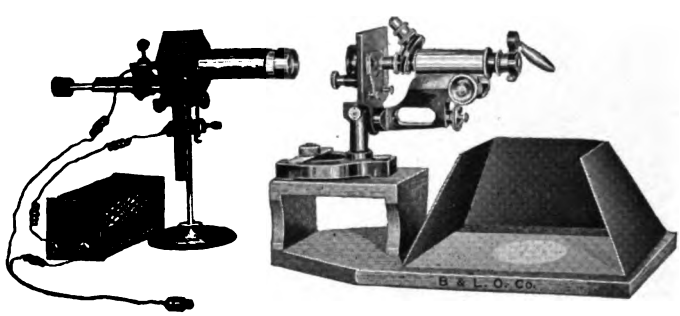

Fig. 14

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Plate XXV

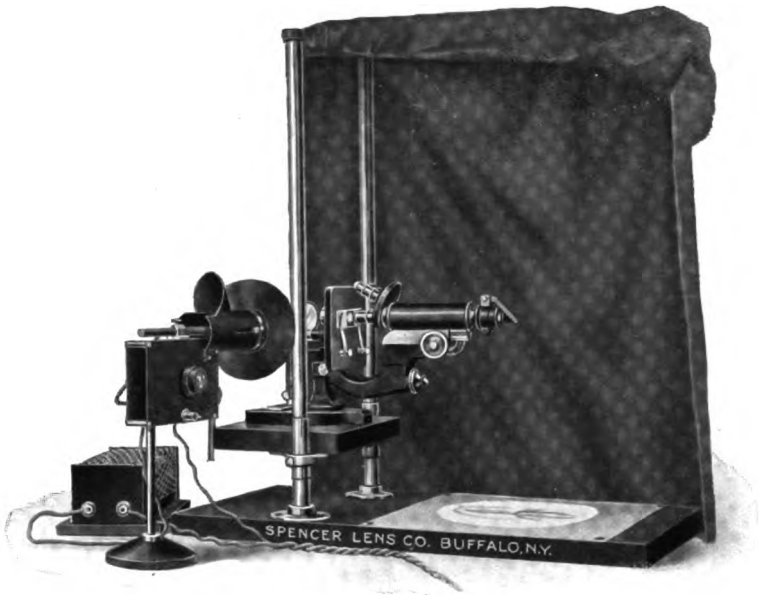

Fig. 15

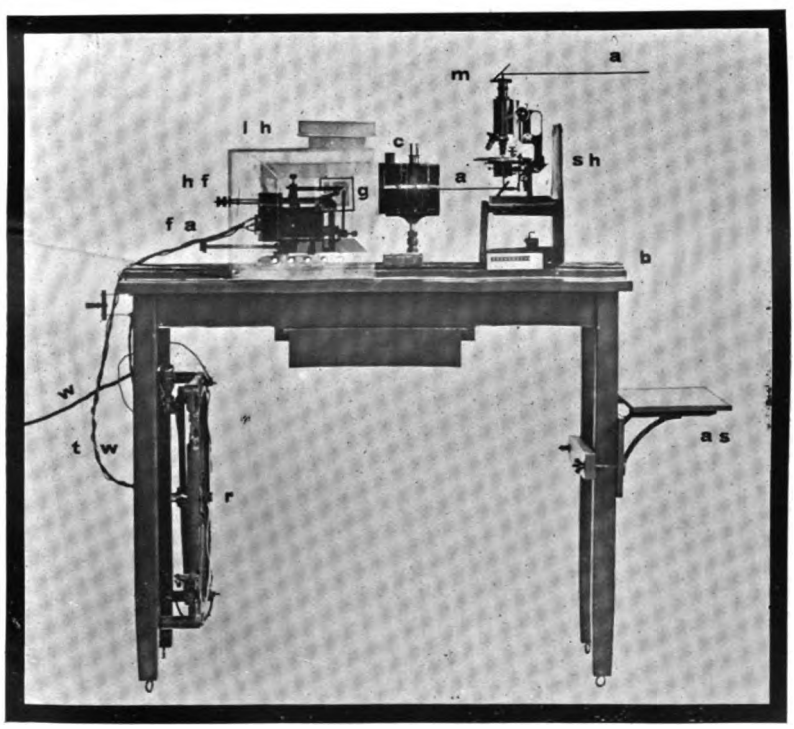

Fig. 16

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PLATE XXVI

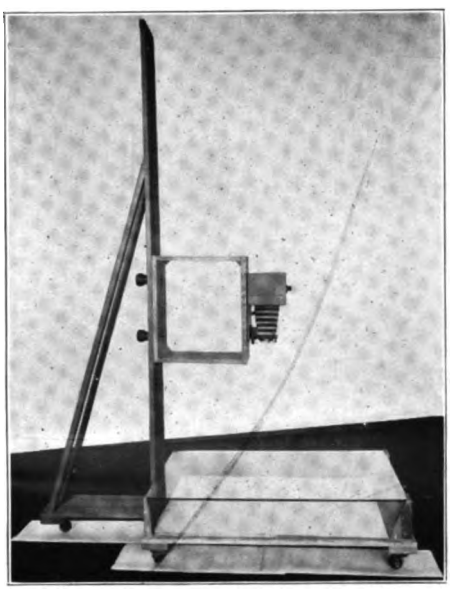

Fig. 1. Convenient Photographic Outfit for Laboratory.

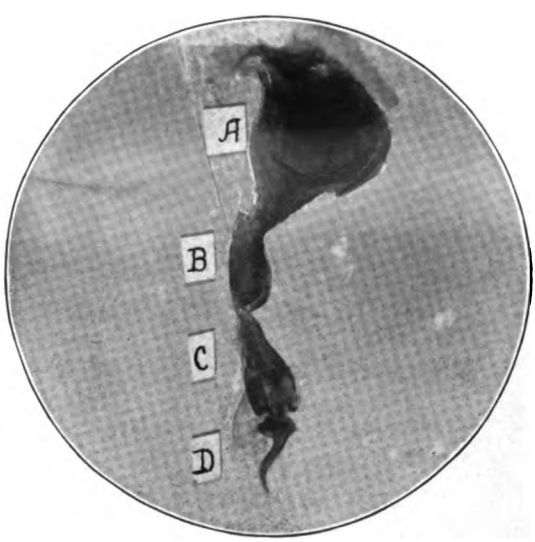

Fig. 2. Intromittent organ of male Odonata.

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PLATE XXVII

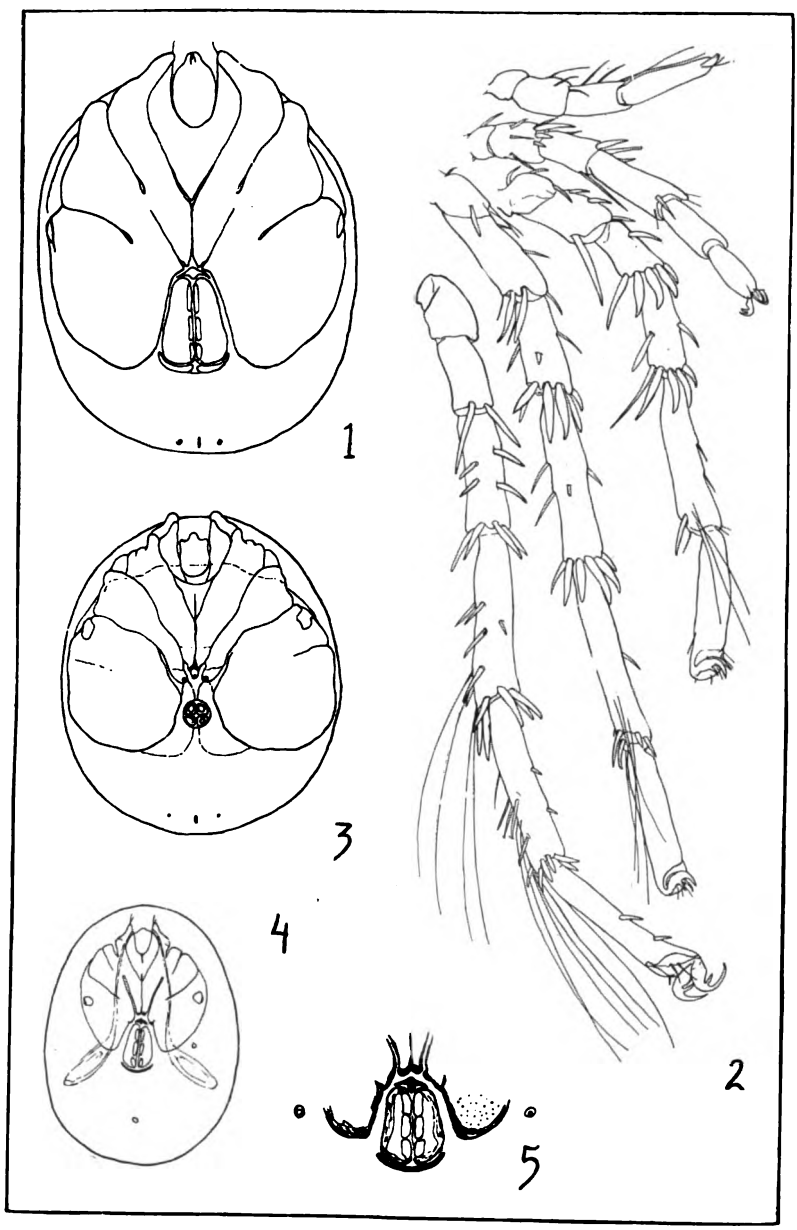

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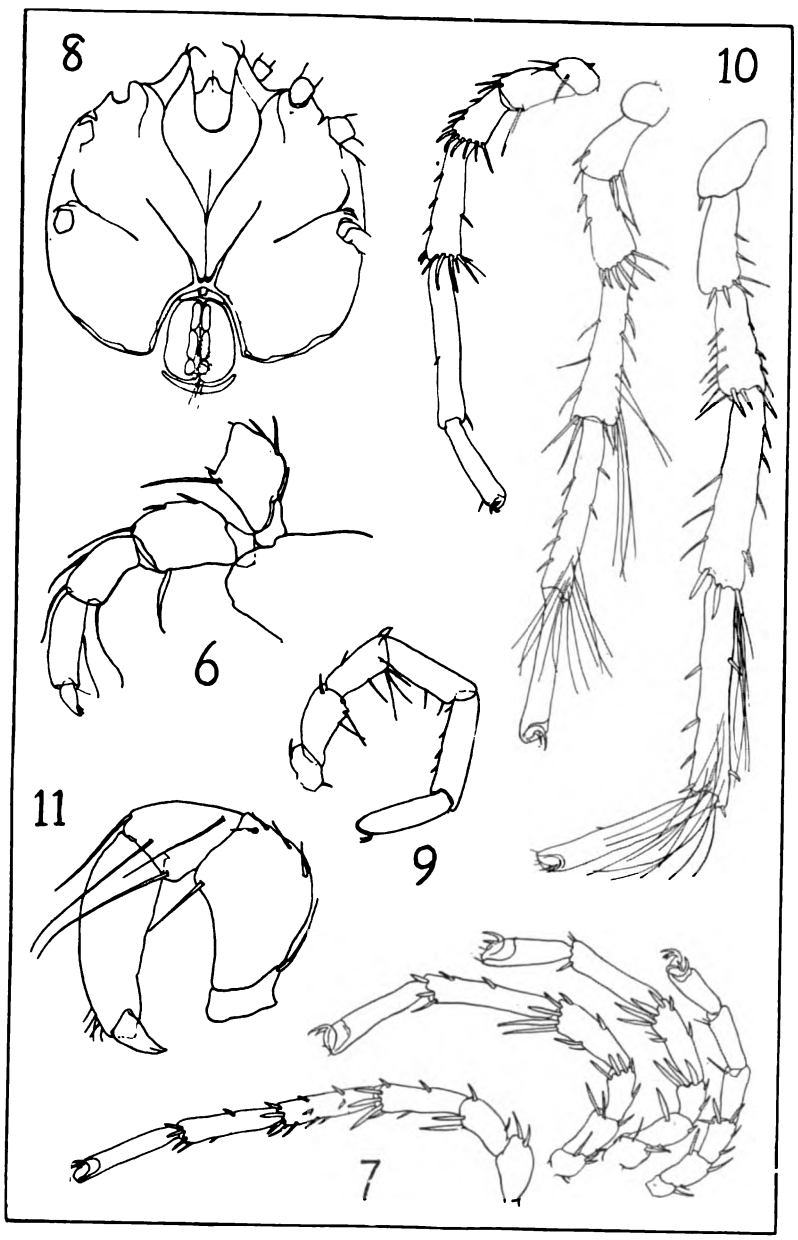
PLATE XXVIII



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